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DRAWING INSTRUMENTS

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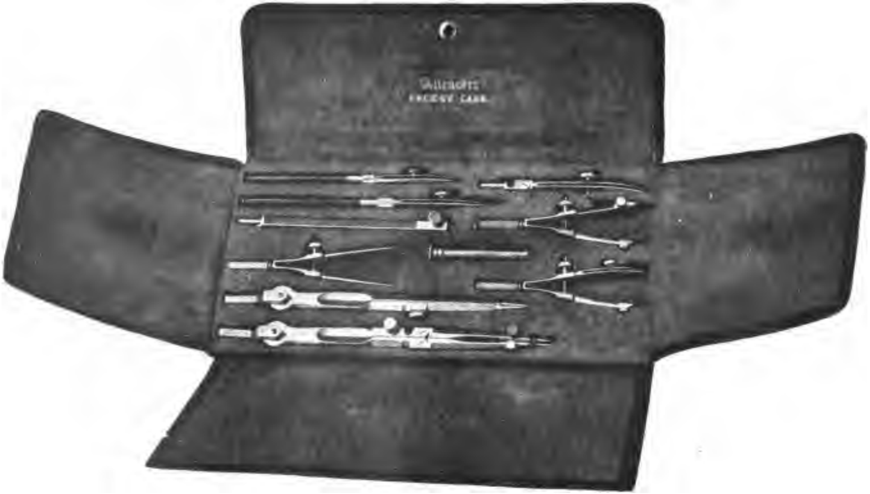

Frontispiece.—Set of Instruments.

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DRAWING INSTRUMENTS

THEIR USE AND ABUSE

BY

WALTER G. STEPHAN, M. E.

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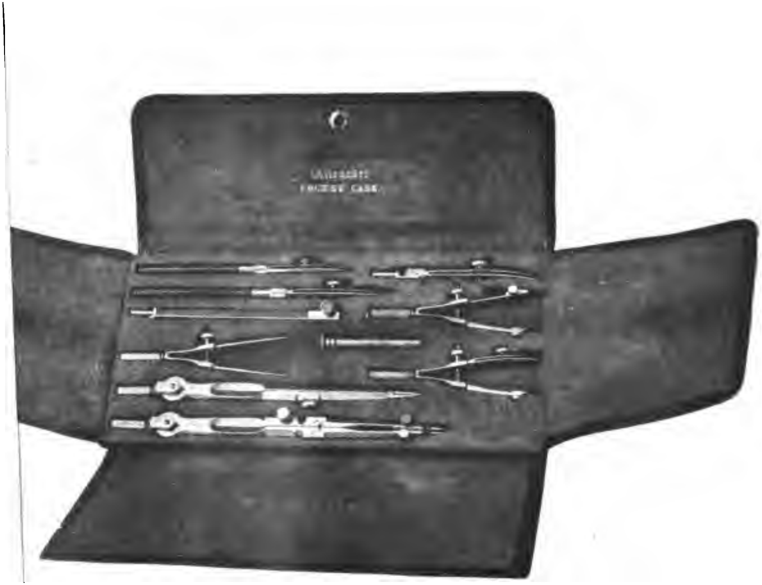

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THEIR USE AND ABUSE

BY

WALTER G. STEPHAN, M. E.

NEW YORK
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239 West 39th Street
1908

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PREFACE.

I wish to acknowledge my indebtedness to Dr. F. M. Comstock of Case School of Applied Science for kindly assistance in compiling this treatise. In gathering together the information contained herein I have consulted several authors, and in some cases have quoted directly from their work.

I wish also to acknowledge my indebtedness to the Keuffel & Esser Co. for furnishing many of the illustrations. If this treatise should prove to be of any assistance to the coming generation of engineers, or if it should meet with favor among teachers of drawing, whose labor it is intended to lessen, the writer will feel well repaid for his efforts in behalf of a better understanding of the use of drawing instruments.

W. G. S.

CLEVELAND, O., JANUARY, 1908.

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DRAWING INSTRUMENTS.

INTRODUCTION.

Before entering upon a course of instruction in drawing at school, or before beginning professional work in the drafting room it is necessary to have tools with which to work. The question arises, what tools will you need and what kind should you buy?

This treatise is intended to aid in the selection of drawing instruments and to discuss their use and abuse. The author knows of no modern treatise on the use of drawing instruments, other than that contained in the manufacturers' catalogues, which necessarily do not cover all instruments made. A careful study of the present day practice in the drawing room has led him to believe that many draftsmen are very careless of their tools and are poorly supplied with them. This fact is all the more remarkable because the work of a draftsman is devoted almost entirely to progress in the use of tools and materials. How few men at the drawing table ever think of testing their T squares and triangles and making them true! How few men know how to sharpen a drawing pen properly when it is dull, or even know that it may need sharpening! The accuracy, finish and speed of the drawing done by a professional man are dependent in great measure upon the good qualities of his instruments. The more perfect they are in material, form and proportion, the more perfect will be his work, and the more completely will the tool become a part of his very hand; less work being necessary to make the tool respond to his wishes. Good work requires good tools with a live, careful man behind them. Why not learn to test your own instruments and know for yourself that they are of good quality and are accurate? This is good sentiment:

> " If a cobbler by trade, I'll make it my pride,
> The best of all cobblers to be.
> And if only a tinker, no tinker on earth
> Shall mend an old kettle like me."

With proper care a set of good drawing instruments should last a lifetime, consequently it is important to buy intelligently and to use them carefully. For the very beginner it is well to buy an inferior set to be used until he becomes proficient and can be trusted to care for a good one, but for the professional beginner it is poor policy to buy inferior instruments—*it does not pay.* Rather buy a few good instruments—the essential pieces only —and add to them as you are able. There is nothing so trying to a draftsman as a tool which refuses to work properly just when it is needed most, and there is nothing more satisfying than the thought that one's tools are good and can always be depended upon. The qualities of well-made instruments will last, so that one can become so familiar with their " feel " and the location and movement of every part, that they are adjusted instinctively.

In the first place, go to a reliable dealer. He will have in stock some of the best makes. The name of the maker is the best guarantee of quality. The durability and efficiency of drawing instruments depend upon the kind of metal employed and upon careful, conscientious workmanship, together with correct proportions.

The best instruments are made of hard-rolled (not cast) German silver body, with steel threads and joints and with tempered steel springs and points. They have good proportions and are stiff though light in weight, convenient to handle and have delicate adjustments. Their finish is the superior finish given only to good mathematical instruments. The grain left from the finish of surfaces should be at right angles with the length of the instrument. It should in all parts show an equal and very fine grain surface but not a burnished gloss. Good instruments are never nickel plated. Inferior ones are made of cast or coined metal body with iron points. They are clumsy in design, are heavy and their joints are not uniform in their movements. Their finish is easily distinguished because of its glossy burnished surface.

Aluminum has of late years been introduced in the manufacture of such parts as the handles of drawing pens, etc. It is an excellent material, non-corrosive and extremely light.

There are two sizes of instrument sets, six-inch sets and four and one-half inch sets. These terms are applied to the whole sets although only the compasses and the drawing pens have the lengths from which the set is named. Six-inch sets of instruments are best suited to and most used by engineers. Four and one-half-inch sets are usually sold in pocket cases.

Regarding the care of the drawing instruments in general. Remember that all metal tools should be wiped *dry* before laying them away. Perspiration from the hands will tarnish them very quickly. Chamois is excellent for cleaning, although any clean soft cloth will answer. *Points, pens and joints are the most important parts.* It is well to use a cloth slightly oiled occasionally, care being exercised not to allow the oil to soil either the hands or the paper when in use. What is known as 3-in-1 gun oil is very good instrument oil. Keep the tools in a case; they are kept clean, and loaned tools are readily missed when not in place.

Instruments may be carefully preserved by merely rolling them up in a piece of soft leather, leaving space between them so they cannot rub on one another. Still better is a soft leather or chamois case having pockets for the separate instruments.

It is difficult to draw a sharp line between the necessary tools and the unnecessary tools. A skilled draftsman could *if necessary* make a drawing with only pencil, paper, straight edge and a pair of compasses. However, the following is a list of the tools which are commonly considered necessary for making drawings:

1. Drawing board, paper and thumb tacks.
2. Pencils (hard and soft).
3. T square.
4. Triangles, 45° and 30°/60°.
5. Scales.
6. Protractor.
7. Compass.
8. Divider.
9. Ruling pen.
10. Eraser.
11. India ink.
12. Pen and holder.

The above list includes only essentials. A complete outfit is listed in the following pages under the first heading, " How to purchase drawing instruments." It is scarcely necessary to add that drawings can be made much more easily and rapidly with the complete set of tools listed.

Each item is considered separately in the regular text, and under each heading are discussed the various kinds of instruments manufactured, their uses, their abuses, how to care for them and how to test their accuracy. One general principle should be emphasized in regard to the design of drawing instruments—they should never be circular in cross-section throughout their length because they will roll off the inclined board if they are. It is for this reason that drawing pencils are made hexagonal in cross section by all manufacturers.

Some may question the arrangement of tools as followed in the text; that is to say, the placing of drawing board, T-square, triangles and drafting machine before the compass, divider, etc., but when it is remembered that fully 90 per cent. of the lines on the ordinary drawing are straight lines, the logic of this arrangement must be admitted.

HOW TO PURCHASE DRAWING INSTRUMENTS.

This chapter is intended to be a practical guide for the student or professional beginner who is about to buy his outfit for making drawings, and who is assumed to know very little about instruments, either as to quality or number required. In it will be given a list of the instruments which make up a complete drafting equipment. The student can make a choice from this list according to his purse. Only *good tools* are included, taking it for granted that he wishes to buy tools which will, with proper care, last a lifetime. This policy is one of real economy. Moreover the list includes only items which every draftsman should own.

In the treatment of the separate instruments, tests are briefly indicated which can readily be made by any one at the dealer's and which will help materially to give the beginner, not only a good set of tools, but also a proper conception of the usual faults of poor and inaccurate ones.

Many of these tests are repeated under the various headings which follow in the regular text and which the student can refer to for a more detailed treatment.

COMPLETE DRAFTING EQUIPMENT.

One drawing board ($1.25 to $2.00).
Drawing paper.
Thumb tacks (10c. to 15c. doz.).
HHHH lead pencils (10c. each or $1.00 doz.).

HHHHHH lead pencils (10c. each or $1.00 doz.).
Soft lead pencils (5c. each or 50c. doz.).

One T square (75c. to $1.50); One 6 inch 45° triangle (55c.); One 10 inch 45° triangle ($1.10); One 8 inch 30°/60° triangle (55c.); One 11 inch 30°/60° triangle (85c.); One triangular scale 12″ long ($1.75 to $2.50), or 3 separate flat scales graduated to suit the work to be done ($1.35 each); One triangular scale 3″ long (25c to 50c.); One protractor (35c. to $6.50);	or	One universal drafting machine; sketching device ($14.00 to $17.00), with three sets of scales graduated to suit the work to be done (6 scales at $1.25 each).

One 6″ compass ($7.50 to $8.00);
One 6″ divider ($2.50);
One 5″ ruling pen ($1.25 to $2.50);
One 4½″ ruling pen ($1.10 to $2.50);
One bow pencil ($2.50 to $3.25);
One bow pen ($2.50 to $3.25);
One bow divider ($1.75 to $2.50);
One beam compass ($7.00 to $9.00);
One slide rule ($4.50);

Pencil erasers (10c. each);
Ink erasers (10c. each);
Bottles india ink, red and black (25c. each);
Two pen holders with writing pens (5c. each);
One erasing stencil (20c. each);
One prick point (25c.);
One french curve (60c to 75c.);
One pencil sharpener (10c.);
One soft cleaning rubber (10c.);
One horn center (10c.);
Bottle Higgins' drawing board paste (small 15c.; large 25c.);
Box powdered pumice (20c) ;
One dust brush (25c.);
One Arkansas stone (50c.);
One sponge.

If water coloring is to be done a few half-pan colors with double-end camel's hair brush will be needed—also a nest of 6 cabinet saucers and a stick of India ink.

In the following paragraphs are given brief directions for those purchasing the tools mentioned in the preceding list.

Drawing Board.—The board should be made of ⅞-inch soft pine, straight grained. It must not be warped. It should have hard wood cleats dovetailed into the back. Order one at least 2 inches longer and wider than the largest drawings to be made—6 inches longer and wider would be better. 26 in. by 38 in. or 23 in. by 31 in. are convenient sizes. Test the left hand guiding edge for straightness by comparing it with a known steel straight edge. To test the steel straight edge draw a line with a hard sharp pencil the entire length, then reverse the edge and draw another line over the first. If the two coincide everywhere, the edge is straight (see Fig. 9).

Drawing Paper.—This must be ordered to suit the work to be done. Whatman's not hot pressed paper is used in schools very largely and can be bought in pads of various sizes. It is watermarked with an " N " which can be plainly seen by holding the paper up to the light. Manilla paper is a cheaper paper used for rough pencil drawings and can be bought in rolls and in various grades. It is used commercially where drawings are to be traced on tracing cloth. Test its toughness by tearing a piece. Rub it vigorously with an eraser and see whether its surface is still good.

Thumb Tacks.—These can be bought by the dozen or by the gross. The well-made steel or brass tacks are most economical in the end. Those about ⅜ in. or 7/16 in. diameter are most convenient. The very best thumb tacks are made of one piece of metal with no joints.

Lead Pencils.—Hardtmuth's Koh-i-noor or A. W. Faber's Siberian pencils are of good quality.

T Square.—Buy a T-square longer than the longest drawing to be made and not quite as long as the drawing board. 24-in. and 36-in., lengths are standard sizes, the latter preferred. The T-square with transparent celluloid edges is recommended. See that the blade is straight-grained and is firmly fastened to the head and test both the top ruling edge of the blade and the guiding edge of the head for straightness by reversion and comparison as previously described under drawing board (see Fig. 9).

Triangles.—Buy transparent celluloid triangles with finger bevels for lifting them from the board. Choose the thicker triangle where there is any choice. Test all the edges for straightness by reversion as previously described under drawing board.

Test all the right angles by placing one leg firmly against a true straight edge and drawing a fine line carefully with the other leg. Revolve the triangle about the line drawn (without moving the straight edge) and draw a line over the first one with the same leg. If the two lines coincide, the angle is a true right angle (see Fig. 14). Now test the 30°, 60°, and 45° angles by first constructing these angles carefully by geometry (see Fig. 15) and then comparing them. A perfectly true triangle can rarely be found. Select the best ones.

Scales.—Buy either one triangular scale 12 in. long or three flat scales. If you are to do mechanical or architectural drawing, buy what is called the "architect's triangular scale" (Fig. 20). If civil engineering is your work, buy the "engineer's triangular scale" (Fig. 21).

The steel scale is convenient because dimensions can be "pricked off" from it very accurately, though many prefer those with celluloid faces.

The very best scale sections, for convenience in handling, are those of the cross-section, shown in Fig. 1.

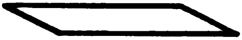


FIG. 1.—Cross-section of flat scale.

They can always be picked up readily. For a mechanical engineer choose three scales of this section graduated as follows on their opposite celluloid bevels:

One scale—Inches and 50ths.

$$\text{One scale}\begin{cases}1\frac{1}{2}\text{ in. and 3 in.}\\ \frac{3}{4}\text{ in. and }\frac{3}{8}\text{ in.}\end{cases}$$

$$\text{One scale}\begin{cases}1\text{ in. and }\frac{1}{2}\text{ in.}\\ \frac{1}{4}\text{ in. and }\frac{1}{8}\text{ in.}\end{cases}$$

For the civil engineer choose three scales graduated as follows:

$$\text{One scale}\begin{cases}1\text{ in. and }\frac{1}{2}\text{ in.}\\ \text{10ths and 50ths.}\end{cases}$$

$$\text{One scale}\begin{cases}1\frac{1}{2}\text{ in. and 3 in.}\\ \text{inches.}\end{cases}$$

$$\text{One scale}\begin{cases}\text{30ths and 60ths.}\\ \text{20ths and 40ths.}\end{cases}$$

The triangular scale 3 in. long is very convenient for small work.

Protractor.—The transparent celluloid semi-circular protractor is good. Brown & Sharpe's steel protractor (Fig. 24) is excellent. Test all the common angles by constructing them geometrically and comparing them (see Fig. 15).

Universal Drafting Machine.—For the student, the sketching device (see Fig. 26) is recommended. This takes the place entirely of the four preceding items, viz., triangles, T-squares, scales and protractor, as indicated in the list. It is considerably more expensive than those items all together, but it saves much time and labor in the handling of those tools. It is accurately made and should last a lifetime. Furthermore it is the "up-to-date" drafting tool and there is nothing like being started right.

Compass.—The body of the compass should be made of rolled German silver. It should have a fine instrument finish, nice proportions and a pivot joint, (see Fig. 29). Try all the joints for even movement throughout. Test the knuckle joints for alignment (see Fig. 28). See that the clamp socket holds both pen and pencil legs firmly with no "play" in the joint (see Fig. 31). See that the lead is adjustable and well protected from danger of breaking. See that the needle point is adjustable and has shouldered points (see Fig. 28).

Divider.—The divider should have a rolled German silver body. It should have a fine instrument finish, nice proportions and a pivot joint (see Fig. 33). It should also have steel points, ground conical and of equal length, and a hair-spring adjustment on one leg.

Ruling Pens.—They should have sharp nibs cut from one piece of steel, of equal lengths and nicely rounded. Draw fine and heavy ink lines of different width and note whether lines are all sharp. The nibs should open wide enough so that cleaning can be done easily. Theodore

Alteneder's lever pen (Fig. 36) is an excellent one—it is easily cleaned. Kern's Swiss pens are a standard make.

Bow Instruments.—They should have a fine instrument finish, and should be cut from one piece of steel. The springs should not be too strong for the fingers. The leads and needle points should be adjustable and the needle points should be shouldered (see Fig. 42).

Bow divider legs should be of equal lengths. Draw large and small circles with fine and coarse lines by means of the bow pen and note whether all the lines are sharp.

Beam Compass.—The Swiss type of beam compass (Fig. 52) is the most practical because the attachments will fit several lengths of beam. The beam should have a shoulder on it to keep the attachments from falling off, as shown in Fig. 52.

Slide Rule.—The common straight rule about 10 in. long will suffice for all ordinary work. The rider should be a metal frame with glass or celluloid window—the old style toothed metal rider is not as convenient. See that all the divisions are opposite when the slide is in and the zero points are opposite. Test the rule for several simple operations. If it is inaccurate, return it to the dealer. See that the movement of the slide is even throughout the entire length—this is very important. Keuffel and Esser's slide rule is preferred, though A. W. Faber's Mannheim rule is good.

Erasers.—Do not buy steel erasing knives. Use the common india rubber erasers. Buy either a sponge rubber or a block of art gum for cleaning drawings.

India Ink.—Higgin's waterproof India ink is good. It is sold in small bottles with quill in cork for filling pens. Post's India ink is also good.

Lettering pens.—Pens are largely a matter of personal preference. A pen with a long nib usually makes a good lettering pen.

French Curve.—Buy a transparent celluloid curve. A simple curve about 8 in. long will serve for all ordinary purposes.

Pencil Sharpener.—Buy either a fine file or the common sandpaper pad mounted on a piece of wood with a handle (see Fig. 44).

Horn Center.—A plain disc of horn or transparent celluloid with three sharp needle points is a satisfactory article. See that the body is not warped.

THE DRAWING BOARD.

The drawing board (Fig. 2) should be made of selected kiln-dried soft pine about $\frac{7}{8}$ inches thick, with dove-tailed hardwood cleats fitted into the back to prevent warping. It should also have hardwood straight edges securely glued to each end and should be at least 2 in. longer and wider than the drawings to be made; 6 in. longer and wider would be better. The top surface of the board should be perfectly plane and the working edge (usually the left hand edge) should be *perfectly straight.* It is not essential that two adjacent edges of the board should be at exactly right angles, although it is convenient to have them so for drawing border lines. The working edge should always be tested for accuracy. This is best done by comparison with a known steel straight edge. If the working edge of a board is inaccurate all the work on the board will be more or less inaccurate, no matter how good the other tools are.

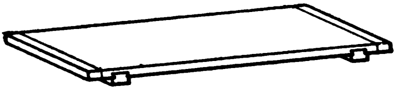


FIG. 2.—Drawing Board.

Another test for the working edge is as follows: With any *accurate T-square* and a hard pencil carefully draw a line along the middle of the drawing paper from edge to edge. Using this line as a line of centers and with equal radii, describe arcs at the top and bottom of the paper as shown in illustration Fig. 3. Now draw lines tangent to these arcs, with the T-square pressed firmly against the working edge. If the lines are everywhere tangent to the arcs, the edge of the board is true.

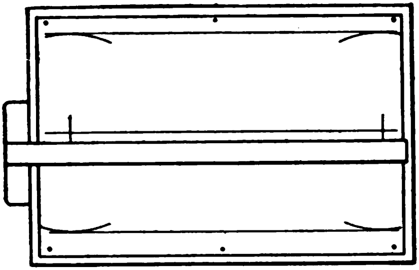


FIG. 3.—Drawing Board Test.

Some draftsmen have planed steel bars or shapes fastened to the left-hand edge of the drawing board and in this way maintain a very accurate working surface, requiring no attention at all.

DRAWING PAPER.

Drawing paper should be strong, uniform in thickness and surface, neither repelling nor absorbing liquids. It should not become brittle or discolored with age and should be such that a clean, sharp ink line of any width can be drawn upon it. It should not crease deeply under normal hand pressure applied to a hard pencil, and should stand a reasonable amount of erasing without being made unfit to take ink. Usually there is a right and wrong side to drawing paper. That side from which the maker's name can be read when held up to the light is the drawing side—its surface is supposed to be more uniform. If the paper is rolled, the inside surface of the roll should be the working surface, because it is more apt to be clean. Perhaps the best drawing paper manufactured is Whatman's hand-made paper. Each sheet is water-marked with the name " Whatman." These papers are made with three different styles of surface:

1. *Hot pressed* (marked H P) which has a smooth surface and is used mostly for pencil and fine line drawings.

2. *Not hot pressed* (marked N) which has a finely grained surface and is used for water color drawing, and general purposes.

3. *Rough* (marked R) which has a coarse grained surface and is used for sketching.

Before using Whatman paper it should be stretched tight on the drawing board. Proceed as follows: (see Fig. 4).

First hold up an edge about ½ in. wide all around the sheet, making it pan shaped—the idea being to keep the edges dry for the paste. With a sponge wet the body of the sheet uniformly, finally draining off any excess surface water. Now smear the outside of the up-standing edges with good library paste, and carefully paste the edges down on the board, always working on the edges in consecutive order. Leave the sheet to dry in a clean, dry atmosphere. If the sheet is stretched too much it will crack in drying and if not enough it will bulge—practice alone can dictate the proper amount of stretch to be given.

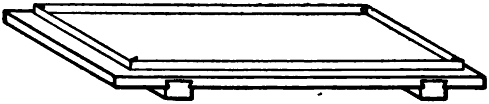


FIG. 4.—How to stretch Whatman paper.

In most drafting offices, drawings are first made with pencil on *brown Manilla paper* and then traced in ink on tracing cloth or bond paper. This is done because erasures and corrections can be made more easily in pencil and because the drawing on manilla paper cannot be reproduced easily. Furthermore the drawing would become dirty and obliterated by constant use. The best grades of manilla paper have a firm surface on which even a hard pencil under normal hand pressure does not make a deep groove, and erasures can be made several times without " flaking." Poorer grades allow the pencil to sink into the paper and make a groove which it is almost impossible to erase.

To fasten the paper to the board, metal *thumb tacks* are used (See Fig. 5). Sometimes common, one-ounce steel tacks are used together with a magnetized hammer which is very convenient. The advantage in using small steel tacks lies in the fact that the tack head can be driven in below the surface of the paper, so that it does not interfere with the moving of T-square and triangles and does not nick their edges. A tack which has recently been put upon the market is the one shown in Fig. 6. This tack is made of but one piece of steel, with no joint, and it has a knife edge which permits of its being forced down perfectly flat upon the paper, so that the T-square and triangle will slide over it without nicking. In addition it has two holes in the curved top through which it can be removed without injuring the head, by the use

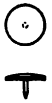


FIG. 5.—Thumb tack (common).

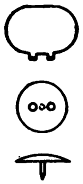


FIG. 6.—Thumb tack(Universal Drafting Machine Co.).

of a small thumb key. This tack is more expensive than the ordinary make but its life is very much longer.

Tracing cloth is a durable, transparent linen cloth especially prepared. It has usually one glazed and one unglazed surface, the latter being preferred for the working side. Its transparent quality permits copies to be made by means of the blue, black, or brown print processes. In order to draw on it with ink, its surface should first be prepared by rubbing it with a fine pumice (which can be bought cheaply at any drug store) either applied with the hand or on a cloth. This process removes the gloss and also any grease which may be left on the surface. Tracing cloth expands and contracts considerably due to the moisture in the air. It is therefore a good plan to leave the cloth exposed to the atmosphere of the room for some time before beginning to trace upon it. It is often convenient to stretch the tracing cloth over the drawing to be traced, at night, leaving it so until work is begun the next day. Pencil lines can be removed easily from tracings by benzine applied on a cloth.

Tracing cloth must be handled with some care as moisture from the hand while working on it, will cause it to stretch and buckle.

Tracing paper is a thin semi-transparent paper which can be used in the same way as tracing cloth. It is not very tough, tears easily and stretches out of shape. It serves its purpose on work which is only temporary and not very accurate.

Sectional paper, for sketching to scale or for making small working drawings is very convenient. This is paper ruled over into small squares to a given scale with pale ink. Heavier lines are ruled either to mark off the inches or to count the spaces in tens. This paper is also made up into sketching books and architects' pocket books for which it is particularly convenient.

Where drawings are to be made for the U. S. Patent Office, and also when made to be reproduced by the line etching process for purposes of illustration, the work should be done in ink on *Bristol board* which has a firm white surface and permits of an exceptionally clean-cut line.

THE T-SQUARE AND STRAIGHT EDGE.

The T-square, Fig. 7. is the fundamental tool on the drawing board. All lines and dimensions on the drawing are referred to it directly or indirectly. Hence it is essential that the T-square have a *perfectly straight ruling edge* and that the head be straight and be firmly fastened to the blade at right angles or nearly so. The blade should be stiff and light, the head comparatively heavy. The grain of the wood should be straight and lengthwise of the blade. Usually strips of transparent celluloid or imitation ebony are glued to the blade for a ruling edge. The celluloid makes it possible to see the work adjacent to the line being drawn, which is an advantage. Some T-squares are made with adjustable heads (see Fig. 8) to permit the use of the edge at various angles. This is very convenient but not necessary. All T-squares should have a hole at the end of the blade from which they should be suspended when not in use, so as to prevent warping.

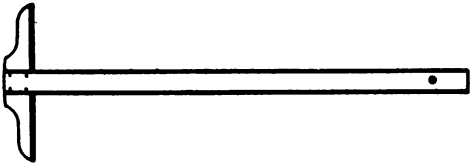


FIG. 7.—T-square with fixed head.

Every T-square should be tested before it is used.—To do this, carefully draw a line with a hard pencil for the entire length of the blade, and with the T-square in its normal position flat on any plane surface. (See Fig. 9). Reverse the T-square with the head on the right hand side of the board and draw a line over the first one—using the same ruling edge as was used before. If the two lines coincide exactly throughout their entire length, the ruling edge is perfectly straight. If they do not coincide exactly, the edge is not true, and the error should be corrected either by the use of a fine sharp plane or fine sand paper on a block. This test applies to the edges of the triangles as well as to any straight edges.

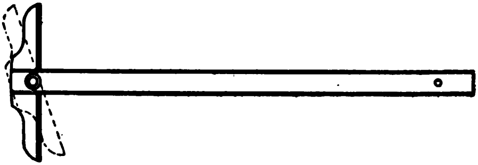


FIG. 8.—T-square with adjustable head.

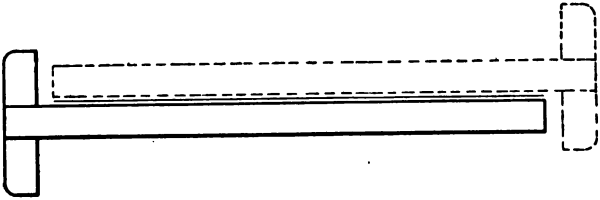


FIG. 9.—T-square test.

The *head* of the T-square or *stock* should also be tested for accuracy. This is done by comparison with a known steel straight edge. The head should never rock on the guiding edge of the board. If it does, either the board or the head or both are not true. The edge of the stock immediately under the blade is bevelled off, or rabbeted so that the stock will only touch the board below the edge, because the extreme angle of the board is liable to become indented and untrue.

Do not think that once having tested and corrected the T-square it will always remain true. It should be tested frequently. No piece of wood is free from possible warping. It is hardly necessary to add that care should be exercised in the use of the T-square so as not to nick the ruling edge. A nick in the edge means a fault in every line drawn with it at that point.

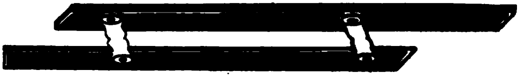


FIG. 10.—Folding parallel ruler.

Parallel Rules.—There are two kinds of parallel rules, the folding and the rolling parallel. One consists of two similar straight edges which have equal metal bars jointed upon them, the joints forming centers about which the instrument moves (See Fig. 10). The figure included between the four joints must be a true parallelogram. The use of these rules is limited by the length of the connecting bars. The second class of parallel rules is called the rolling parallel rule. It consists of a rule of wood or metal on which is mounted along its center line, a pair of wheels of exactly equal diameter united by a long axle. (See Fig. 11).

In using the rolling parallel, the left hand should be placed as nearly as possible upon the center of the rule, so as to secure equal pressure upon the wheels and before moving from line to line the edges of the rule should be tipped off the paper and not be allowed to drag. These rules are useful in cases where large drawings are made which are not fastened down to the drawing board. Their accuracy can easily be tested by drawing a line at the top of the board and a parallel line at the bottom of the board, then moving back to both lines for a test.

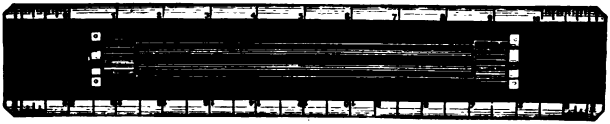


FIG. 11.—Rolling parallel ruler.

THE TRIANGLE.

Triangles or set squares (Fig. 12), as they are sometimes called, are tools with which right angles and angles of 15°, 30°, 45°, 60° and 75° can be directly transferred to the drawing. With them, parallel lines can be readily drawn (see Fig. 13) as well as any other short straight lines. Next to the T-square, they are the tools most used on the board. They are made either of celluloid, hard-rubber, wood or metal; the first two being preferred. The celluloid has the advantage of lightness and transparency and its polished surface does not collect dust readily. Metal triangles are seldom used because they collect dust readily and rust or corrode from the action of the air and moisture. Various sizes are made—those of 45° and 30°/60° being necessary. It is convenient to have large and small sizes of each, because it is

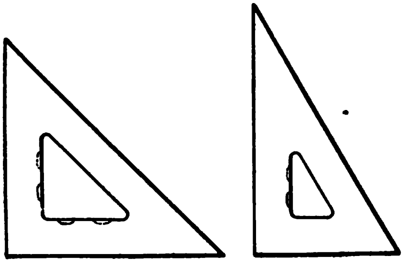


Fig. 12.—Triangles.

awkward to try to draw small figures with a large triangle, and vice versa.

All triangles should be tested not only for straight edges, but also for correct angles. They are more often inaccurate than accurate. To test a triangle an accurate straight edge, a compass, paper and a hard pencil are needed. These can be had at any dealer's. If the dealer should not have an accurate steel straight edge, test the best one at hand by the method of reversion previously described; then test each edge of the triangle for straightness by reversion, and the right angle as follows: (see Fig. 14).

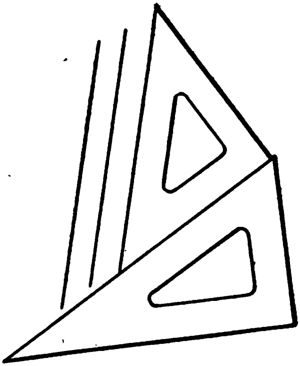


FIG. 13.—How to draw parallel lines.

Press the straight edge firmly on the paper and hold one leg of the triangle firmly against it. With a hard pencil draw a fine line the entire length of the vertical leg. Without moving the straight edge, turn the triangle over about the line drawn as a hinge and with the same leg firmly pressed against the straight edge draw a line over the first.

If the two lines coincide the angle is truly 90°. If not, the angle is inaccurate.

To test the 45° or 30°/60° angles construct these angles carefully by geometry with the straight

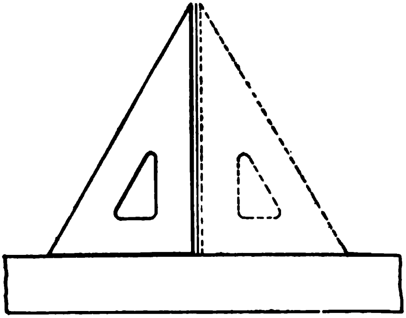


FIG. 14.—Right-angle triangle test.

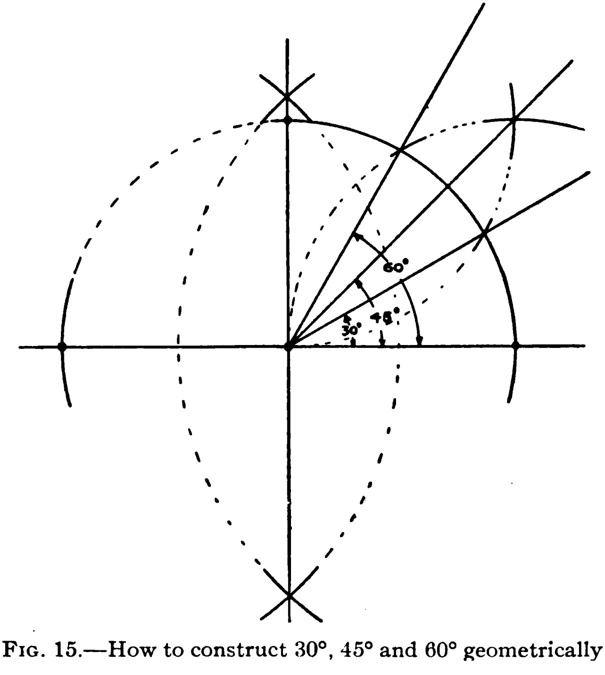


FIG. 15.—How to construct 30°, 45° and 60° geometrically

edge and compasses (see Fig. 15) and compare them. It is not easy to find a perfectly true triangle but it is well to try all the dealer has and select the best. A sharp plane or sand paper will remedy any fault. Triangles as well as T-squares should be tested frequently, as they warp and draw out of shape.

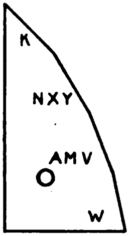


FIG. 16.—Lettering set square

Some draftsmen purchase a large piece of celluloid and cut from it their triangles. This is easily done and permits one to make special shapes to suit individual taste or to suit special work. For example it is very convenient to have a shape which will give both bevels of the flanges of rolled steel I-beams and channels.

Lettering-set squares (Fig. 16) are made having several bevelled edges which give the inclinations of the various parts of capital letters. These are very cheap and convenient where a great deal of such lettering is done. However, excellent lettering plates are now printed which make the art of lettering a drawing very simple indeed. The letters can be traced directly on to the drawing by shifting the lettering plate.

SCALES.

The essential requirement of a scale is that it be an accurate measure. It should be straight and be made of some permanent material, its graduations should be distinct and easily transferable to the drawing. The scale most commonly used is a scale of triangular cross-section 12 in. long. Its great advantage lies in the fact that it has eleven sets of graduations, thus replacing eleven separate scales. Its disadvantage lies in the liability of mistaking the proper scale, and also in the angle at which the graduations lie to the paper. Flat scales present the divided surface nearly on the plane of the paper, (see Fig. 17, of which sections, No. 3 is the best because it lies flat and still can be picked up easily). The danger of mistaking the proper divisions on the triangular scale can be

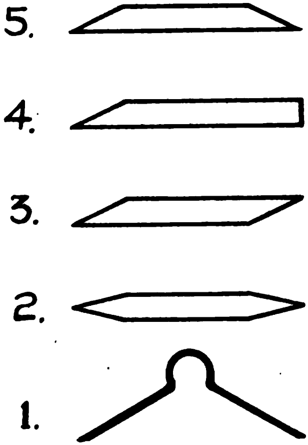


FIG. 17.—Scale sections.

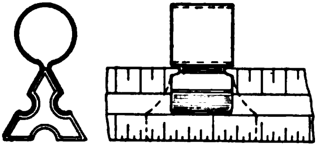


FIG. 18.—Scale guard.

eliminated by the use of a *scale guard* as illustrated in Fig. 18. This is a piece of sheet metal bent to fit the triangular section of the scale and to form a ridge for handling the scale at the top. One side of the guard is longer and *covers* the divisions on that side. On the other side the guard is short and *leaves exposed* the divisions of the scale to be used.

Scales should be made of well-seasoned boxwood or metal, the latter being preferred because it is more constant in length, although its metallic lustre is an objection. Very often the graduated edges of wood scales are made of white celluloid to make the divisions more legible, but as this substance expands and contracts somewhat, the scale is liable to become inaccurate and to crack off.

Draftsmen frequently use the graduations of wood or celluloid scales for setting their compasses directly. This is bad practice as very soon the divisions are erased by the repeated pricks of the points.

Transfer distances directly from scale to paper whenever possible If a metal scale is used it is very convenient and accurate to transfer distances with a *prick point* (which is a common fine needle set firmly into a handle. See Fig. 19). The needle follows the groove of the graduations and marks more accurately than a fine pencil point.

There are two kinds of scales in common use, the *architect's scale* (Fig. 20) and the *engineer's scale* (Fig. 21). The former is based upon the

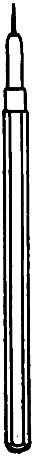


FIG. 19.—Prick point

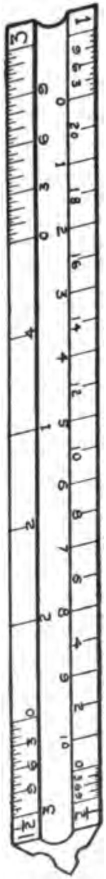


FIG. 20.—Architect's scale.

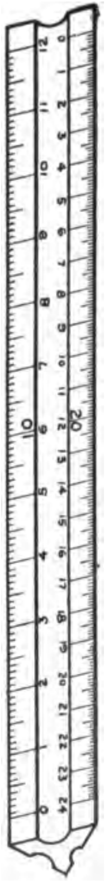


FIG. 21.—Engineer's scale.

duodecimal system (a base of 12) while the latter is based upon the decimal system (a base of 10). The architect's scale is divided into feet and inches while the engineer's scale is divided into tenths, twentieths, thirtieths, fortieths etc. of an inch. The reason for the divisions on the architect's scale is evident from the fact that all our ordinary measurements are based upon 12 inches to the foot. Such scales are also used by mechanical engineers. The *engineer's scale* is used by civil engineers, for plotting stress diagrams, for drawing cross-sections and all work in which the actual measurements taken are based on the decimal system. This covers all work which has been done by the surveyor's transit or level.

Many beginners find great difficulty in understanding ordinary scales so a brief explanation may not be amiss.

In making drawings of objects it is evident that most of them cannot be drawn full size. They must be drawn smaller—either ½, ¼th 1/12th—their actual size in order to get them on an ordinary drawing board.

So, if we wish to draw the object ¼ as large as it is, then for every 12 inches on the object we must lay off 3 inches on the drawing. That is to say three inches on the drawing represents a foot in the actual object. Now if, instead of dividing the dimensions of the object by four each time, we space off several lengths of 3 inches on a straight edge, each space will represent one foot. Also if we divide one of these spaces into twelve equal parts, each part will represent one inch, and so forth, down to a fraction of an inch.

So with the scale thus made we can lay off the measured distances directly on the paper without any mental division. The scale thus made is a ¼ scale or a scale of 3 inches to the foot, and it is marked with a figure 3 at the end of the graduations. In order to facilitate laying off required lengths quickly from such a scale, the end division of 3 in. is divided into twelve equal parts (representing inches and fractions thereof) and the next following division is numbered 1, meaning one foot. (See Fig. 22).

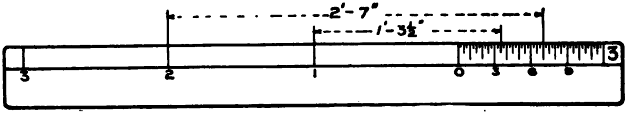


FIG. 22.—Scale of three inches to the foot.

Just so with a 1/12th scale or scale of 1 in. to the foot. Each inch on the scale represents one foot on the object and each 1/12th inch represents one inch. This scale is marked with a figure 1, at the end of the graduations.

It will be found somewhat confusing at first to read the ordinary commercial scale, because the manufacturer has economized space by combining two scales on one set of graduations—one of the scales being twice as large as the other. For example, the scale of 1½ in. to the foot is combined with one of 3 in. to the foot, and the small graduations for one are at one end, while those for the other are at the opposite end. (See Fig. 20). Each end is marked with the figure 1½ or 3 to correspond, and the number of the foot graduations of the two scales are on different levels and read in opposite directions.

THE PROTRACTOR.

One of the most difficult operations to perform accurately is to divide a circle into equal parts. And yet it is upon this very operation that the accuracy of many scientific observations depend. To astronomy it affords the means by which the heavens and the earth are measured. It has taken much time and tireless labor in the past to acquire the accuracy of which we can now make use. For scientific purposes the circle has been divided into 360 degrees, each degree into 60 minutes and each minute into 60 seconds. For laying off these degrees and fractions thereof directly on to paper, the protractor has been made. It is ordinarily a circular or semi-circular piece of celluloid, paper or metal with its rim divided into degrees and half

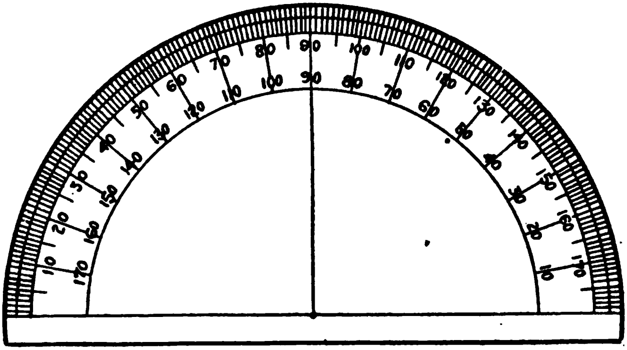


FIG. 23.—Semicircular protractor.

degrees, this being the closest dividing required for common work. However, more accurate instruments are made which are provided with verniers for reading closer than half degrees. The vernier is an ingenious device for subdividing, which depends upon the principle that the eye can tell whether two lines are continuous or broken, although it can not measure the gap between them.

Two kinds are illustrated (Figs. 23 and 24) the metal one (Fig. 24) being a very convenient tool

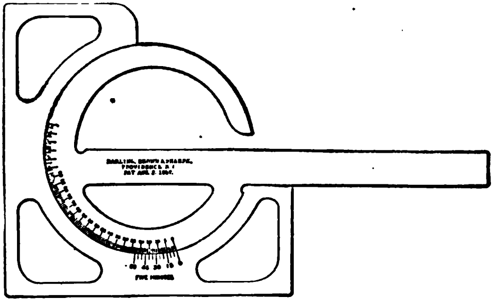


FIG. 24.—Brown & Sharpe's protractor.

to use on the drawing board, as the inclined line can be drawn directly from the instrument without marking first. One ingenious mechanic has devised a method of keeping this protractor away from the drawing so that it does not soil it so readily. At four points in the instrument he drilled holes for steel balls slightly larger in diameter than the thickness of the metal. The balls are made a press fit in the holes and project on each side so that the instrument is held off the paper, no matter how it is used. In buying a protractor it is well to test all the common angles by geometry.

THE UNIVERSAL DRAFTING MACHINE.

Since the perfection of tracing cloth and the blue print no single item has so completely changed the work on the drafting board as the machine which is the subject of this chapter. Although it has been on the market but a few years it has met with great favor among progressive men who are interested in the work done in the drawing room. The machine was the result of a determined effort on the part of the inventor to relieve the mind of the draftsman of the manual labor which is largely drudgery, and which constantly distracts his attention from the real problem at hand. Any one who has worked at the drafting table will confess that it takes a great deal of time during the day to shift the tools on the board continually. The work of a draftsman is largely brain work, and requires concentration of thought. It is not merely representing on paper what has already been determined by some one else. The mechanical operations contribute nothing to his progess after the details have been mastered, and detracts from the pleasure of his work.

The drafting machine does away entirely with T-square, triangles, scales and protractor, and is more accurate than those tools usually are.

As illustrated (Fig. 25) it consists of two pivoted parallelograms anchored in a block at the left hand upper corner of the drawing board, by means

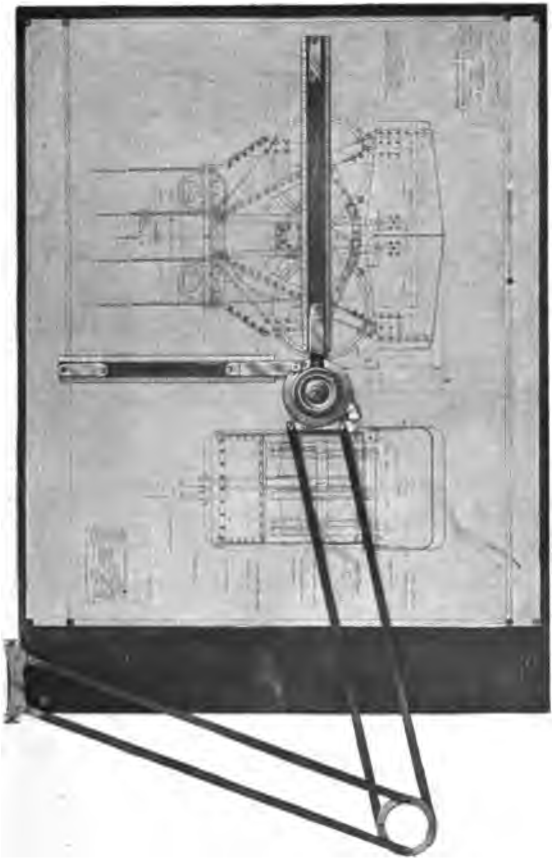


FIG. 25.—The Universal drafting machine.

of which two scale rulers held at right angles in a pivot can be moved accurately parallel to themselves over the entire drawing. By means of a graduated plate and locking device at the pivot, both scales can be turned at once to any angle with the horizontal—the scales always remaining truly at right angles to each other. The scale rulers are interchangeable—each one being provided with a taper chucking plate which fits accurately in the chuck at the center pivot. Any length and any scale can be used.

For inking, a wooden straight edge is provided which is longer than the scales. The parallel arms are made flexible so as to allow the scales to lie perfectly flat upon the paper. They are also hinged at the anchor so that the machine can be easily lifted out of the way of anything on the drawing. The machine can be moved about the board very easily because all of the joints are as nearly frictionless as modern skill can make them.

Spring stops are provided in the protractor at the center by means of which the " scale square " can be set quickly at zero, 30°, 45°, 60° and 90°, greatly facilitating angular work such as is required for the diagonal members of roof trusses and bridge trusses; for graphical statics, etc. Each machine is provided with an adjustment at the pivot plate by which the square can be lined up with the drawing instead of the drawing with the square. The machine is made in three sizes. A modification, called the *rapid sketching device* (Fig. 26) is made—for use on small size drawings.

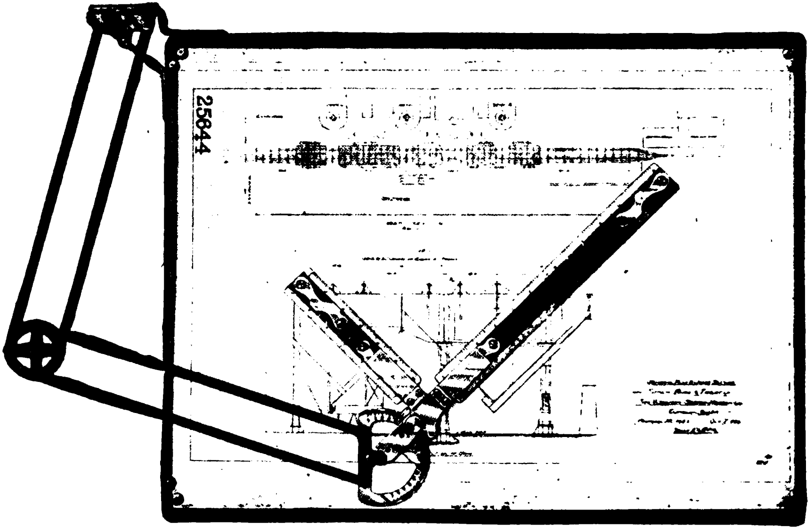


FIG. 26.—Rapid sketching device (Universal Drafting Machine Co.).

It is adapted especially for rapid sketching by the designer, and for the technical student. When using the drafting machine it is well to bear in mind a few points The anchorage to the board must be secure and firm. After a machine has been fastened to the board a short time the fastening screws of the anchor should be tightened again. The drawing board should be about 6 in. longer than the drawing so as to allow the machine to cover it entirely. Where this is not convenient a special anchor can be secured to give the machine the full range of the board. With the standard machines a free space is required to the left of the board which approximately equals in inches the number of the machine. Thus a No. 24 machine requires about 24 inches.

The ring joining the two parallelograms should travel free of the board. Its position is easily regulated by the thumb screw in the anchor, and this screw should be adujsted so that the arm swings in a plane nearly parallel to the plane of the paper. In fastening the machine to the anchor plate care should be exercised to bring up the set screw so that there is no play whatever, but this set screw should not be drawn up with too great pressure. After the set screw has been properly drawn up the check nut should be brought firmly into position.

The pivots used in these parallelograms are all hardened and ground joints and should be oiled occasionally with a good quality of vaseline. In order to do this, the screw holding the washer next to the rod should be removed, the rods slipped off the pin, the pin and hole thoroughly cleaned—preferably with a piece of tissue paper—and vaseline applied, when the joint can be assembled as before. Only one joint should be taken apart at a time so as not to disturb the relative position of the parts of the machine. It is not necessary to oil the joints oftener than once a year, unless the machine is operated over a radiator, where the rising heat is liable to drive off the oil. In this case once in six months may be necessary. If the joint shows the least tendency to bind at any time, it should be cleaned and oiled as described above. The operation takes but a few moments time.

The protractor is made to read to degrees. A half and even a quarter degree may be estimated without difficulty, and in case a finer sub-division is occasionally needed this may be obtained by taking the nearer degrees, marking off this angle with the scale, and making the desired sub-division on a large arc, then setting the scales to it. This will give very accurate results and answers very well indeed where it is only occasionally desired to read very closely a finer sub-division than a quarter degree. In case, such accurate work is required frequently, special protractors may be obtained reading to five minutes or to one minute which can be directly attached to the same arms as the regular protractor.

Protractors having stops for special angles may be secured. Where it is desired to use the protractor for quite a number of readings without the stops, the stop pin is so arranged that it may be lifted out of position and will not act.

The scales forming the square are made with adjustable chucking plates at each end, each plate controlling the alignment of one edge of the scale. The scales should all be tested for alignment by placing one scale in the horizontal chuck arm, being sure that it is properly chucked, and then drawing a line. The scale should then be turned end for end and chucked into position, using the other chucking plate. In case the edge thus thrown in the upper position does not correspond with the line previously drawn, the round headed screw in the chuck plate should be loosened, and the scale moved so as to be in perfect alignment with the line previously drawn, and the screw then tightened again. Each scale to be used with the machine should be tested for each side in a similar manner. A scale should then be chucked into the vertical arm and the protractor swung 90°. If this scale does not then perfectly correspond to the line previously used for testing, the screws should be loosened, the scale moved into position so as to get the vertical chuck arm at right angles to the horizontal chuck arm, and then these screws should be tightened. If for any reasons the scales do not lie flat upon the board. the board should be tested to see if it is

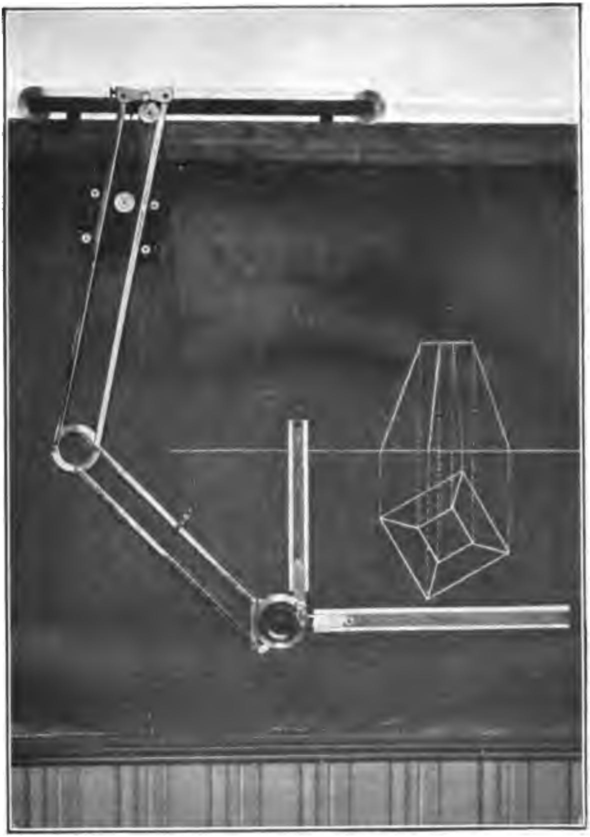


FIG. 26.—Universal drafting machine for use on blackboards.

warped, and if it has warped it should be planed down so as to give a plane surface.

If the board is true and the scales do not lie properly, another set of scales should be put in to see if they act in a similar manner. If they do, a scale should be put into the chuck arm and the chuck arm bent very slightly by holding the protractor in one hand and the scale and chuck arm in the other. This method can then be applied to the other chuck arm if necessary. In case one set of scales lies flat and the other set does not, the scales should be tested on a flat surface to see if they have warped. A very slight warp will not bother much, but if there is any considerable warping the scales should be exchanged for new ones. The scale should also be tested for straightness by laying one down and drawing a line with one edge, then turning the scale end for end and applying the same edge to this line. By using this method any error is doubled and if the scale has warped away from a straight edge to any considerable extent it should be sent back to the manufacture .

In chucking two scales of the same graduations, one into the horizontal arm and one into the vertical arm, care should be exercised to see that the scales are properly chucked into place.

In making drawings with the drafting machine it should be borne in mind that the lines are drawn only the desired length, and being drawn and scaled with the same edge, it does away with a good many of the operations otherwise required in changing tools, and also does away with a great deal of the erasing because it is not necessary to erase ends of lines where they over-run the dimensions desired, for the simple reason that they are drawn in the first place to just those dimensions.

An interesting and valuable feature in connection with the drafting machine is the modification of it which is designed for use on a black board in the school room. The whole machine is mounted on a trolley which runs along a small horizontal rail at the top of the board. The arm of the machine is balanced so that no part of it needs to be supported by the hand. Every foot of a long blackboard can be covered conveniently by this machine and the operator can draw more accurately with it than chalk drawing ever requires.

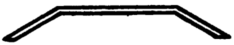


FIG. 27.—Section of scales (Univ. Draft. Mach. Co.).

The metal scales made of the section shown in the cut (Fig. 27) which may now be obtained for use with the universal drafting machine overcome a number of difficulties to be found with wooden scales, and present the following advantages in addition to remaining absolutely straight.

It is found that they can be used with a much thinner edge than wooden scales, thus bringing the graduations closer to the paper, and also that a pencil or prick point may be placed in one of the graduations and moved down until it marks on the paper. By this method a man can learn to work very quickly indeed and with great accuracy. For drawing long lines it is simply necessary to draw the length of the scale and then shift the machine to extend the line to the proper length.

In cases where it is desirable to make long projections, a special attachment can be secured for this purpose, which is much better than a long straight edge. For inking in drawings, a special straight edge is used, and it is found that one about 24 in. long serves best for most purposes. The sweep of a man's hand from one position while inking does not ordinarily exceed 24 ins. Some men prefer to have a vertical straight edge as well as a horizontal one, although this is not necessary as the single straight edge may be set to any position.

For plotting and map work the drafting machine may be obtained with a protractor which has all of the motions of the protractor on a transit as used in the field. With such an arrangement any operation in the field can be duplicated on the drawing, thus avoiding all computations and the necessary chances of error arising therefrom.

The universal drafting machine while a more expensive equipment than others, is especially desirable where it is necessary to produce drawings as quickly and as cheaply as possible and it is well worth the investment to the man who desires to give as large a share of his time and attention as possible to the mental part of drafting and to gain the widest experience in the least possible time.

THE COMPASS.

The compass (Fig. 28) is an instrument for describing circles. It is essentially two pointed legs hinged in a head at the top. One leg is fixed and has a needle point, the other has a socket to receive either a pencil or a pen attachment. The joint at the top is *the important part* of the instrument. Manufacturers have probably given more

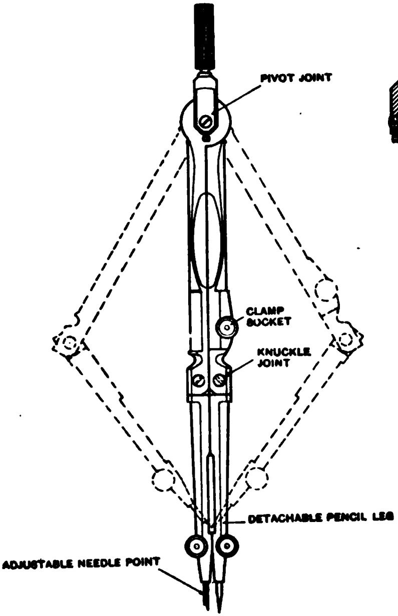


Fig. 28.—The compass.

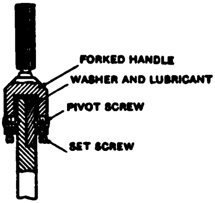


Fig. 29.—Pivot joint.

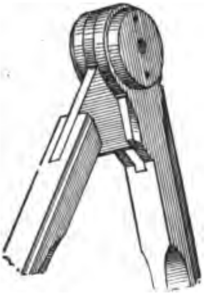


Fig. 30.—The tongue joint.

serious attention to perfecting this, than to any part of a draftsman's equipment. There are two kinds of joints—the pivot joint and the tongue joint. The pivot joint is shown in section in Fig. 29. It consists of a forked handle, in the forks of which are tapped holes for two hardened pivot screws, which press the two legs of the compass together and are themselves held fast by small set screws or lock-nuts. The head of each leg is disk shaped and is countersunk on the outside to receive the pointed end of the pivot screw. Between the two heads is a washer and lubricant of beeswax. This joint is an excellent one. The movement is even and firm throughout its entire motion and it can be adjusted for light or heavy touch as desired. The forked handle is a great convenience and makes the instrument symmetrical and well balanced at all times.

The *tongue joint* consists of a tongue on one of the legs, which moves between two lugs on the other leg. (See Fig. 30). This joint is very inferior and is not used on good instruments. It is not so convenient to handle, its movement is not as uniform and it needs adjusting more frequently than the pivot joint.

The other important points about a compass are the knuckle joints, the clamp socket, the alignment and the points themselves.

The *knuckle joints* are so provided that the legs can always be held at right angles to the paper. They should move evenly and firmly throughout their entire arc of motion and should have screw adjustments and ground bearing surfaces.

The clamp sockets should be such as will hold the removable legs securely in place. There are several kinds of sockets, as shown in Fig. 31.

1. The *pentagonal socket*, which engages a shank of the same shape, and holds it in place by a set screw, which presses on a flat side and forces the bevelled part into a corresponding V in the socket.

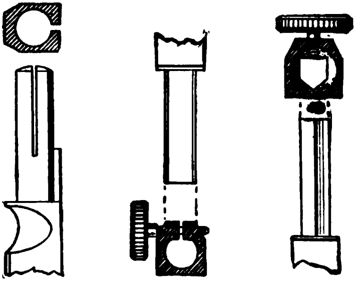


FIG. 31.—Types of sockets.

2. The *round socket* which takes a round shank and holds it in place by the spring of the parts and keeps the leg in alignment by means of a small steel feather.

3. The *clamping socket* which is split and which takes a round tapered shank and holds it firmly in place by means of a side clamping thumb screw. The last two make very rigid joints and secure perfect alignment of parts.

When fastening either a pen or pencil attachment in its socket, it is not necessary to exert all the pressure possible with thumb and finger on the small thumb screw. The shank ought to fit snugly in the socket, and the thumb screw is made just large enough to permit of fastening the same with the normal finger pressure.

The *alignment* of parts is quite important in a compass. It should be tested by bending the knuckle joints, with the several removable legs inserted as shown in Fig. 28 in dotted lines. The points should meet in every position, otherwise the alignment is imperfect.

Compasses are made with fixed pen or pencil points but the " interchangeable " compass with non-detachable needle-point leg and with detachable pen and pencil legs will answer for all ordinary purposes.

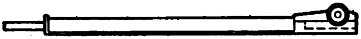


FIG. 32.—The lengthening bar.

The fixed leg should have an adjustable needle point with a shoulder on it to prevent making large holes in the paper. Should this point become dull it can be removed and sharpened—or it can be replaced by a new one.

The point of the needle should be eccentric to the stem to permit of closer setting (see Fig. 28). The pencil leg should permit of clamping the lead securely and should also protect the lead from breakage.

For describing larger circles than about 11 in. in diameter with the ordinary six-inch compass, a *lengthening bar* is provided (see Fig. 32). This is simply a rigid bar on one end of which is a shank which fits into the clamp socket, and the other end of which is a clamp socket which engages the shank of the pen or pencil attachment. The compass when so arranged is quite clumsy and unbalanced, as well as not very rigid. It is much better practice to use a small beam compass than to bother with the lengthening bar.

THE DIVIDER.

The divider (Fig. 33) is an instrument for transferring distances or for dividing lengths into a number of equal parts. Like compasses it consists of two pointed legs hinged in a head at the top, but unlike them it should have no removable legs, so as to insure their always being of the same

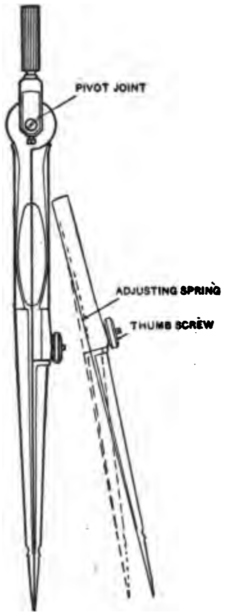


Fig. 33.—The divider.

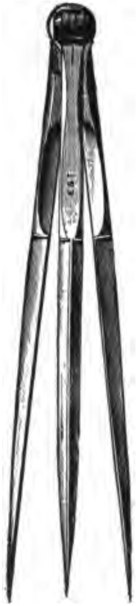


Fig. 34.—The triangular divider.

length. It should have a pivot joint like the compass, and one of the legs should have a *hair-spring adjustment* to permit of delicate setting of the instrument. This adjustment is obtained by jointing the lower half of the needle-point leg to a long steel spring accurately fitted in a slot in the upper part of the leg and attached only at its upper end, the lower end being drawn back against the action of the spring by means of a thumb screw.

The *points* of the dividers should be of high-grade tempered steel and should be ground conical at the extreme lower ends and not triangular in cross section.

By constant use the points of dividers become dull. They should be sharpened occasionally by rubbing on a fine stone, care being exercised to sharpen both legs conical and to exactly the same length.

Triangular dividers are instruments having three legs hinged in a head at the top. They are used prrincipally to copy plots of land or fine art drawings. They locate a third point exactly with reference to two others. (See Fig. 34).

THE RULING PEN.

No instrument which a draftsman uses is more important than the ruling pen and none is in more constant use. There are two principal kinds manufactured, the pen with fixed blades, Fig. 35 and the pen with one blade jointed. A modification of the first is the pen with lever attachment to spread the blades for cleaning (Fig. 36).

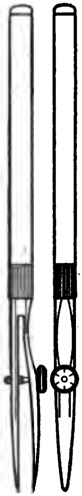


Fig. 35.—Ruling pen with fixed blades.

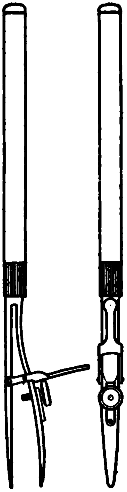


Fig. 36.—Altenederer's lever ruling pen.

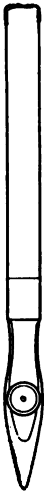


Fig. 37.—Border pen.

A poor pen is worse than useless. Much of the difficulty and annoyance met with in inking a drawing is due entirely to poor pens. A good pen should draw a clear full sharp line of uniform width and should be capable of adjustment for fine or heavy lines as desired. This applies to the pen point of the compass and the bow pen as well.

The *blades* or *nibs* of a plain pen should be cut from one single piece of high grade tool steel properly tempered, and carefully ground and sharpened to an even curve. One point should be straight and stiff so as to resist flexure due to the pressure against the ruling edge, the other being curved and spring tempered. They should be of exactly the same length and *sharp enough to make a crease in the paper* under ordinary hand pressure, but not so sharp as to cut the paper. The creases made in the paper by the points form boundary lines for the flow of the ink from the pen as illustrated in Fig. 38.

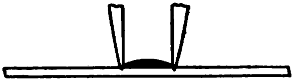


FIG. 38.—Flow of ink from pen.

It is better to make the blades too sharp than not sharp enough. A sharp edge will soon wear down to a working edge. However, if the points are too sharp, the pen is apt to skew away from the guiding straight edge.

The ruling pen requires frequent attention. The operation of sharpening or setting requires considerable judgment and practice, and is one of those mechanical niceties which it is difficult to describe.

To sharpen or set a pen, first screw the blades close together and rub the points round to the curve desired on a fine Arkansas stone. If the pen is very badly nicked or worn, it may be necessary to use a coarser stone at first, otherwise the operation would be too tedious.

A good plan is to lay a triangle flat on the stone, then draw the pen along, as if actually ruling a line, but changing the inclination of the pen continually in the direction of motion, back and forth so as to round the point evenly. By this method, the blades are ground exactly alike under working conditions. (See illustration, Fig. 39). Now spread the pen points and sharpen each nib separately by rubbing its outside surface only on the stone. *Never touch the inside surface of the pen* with anything hard. Use a magnifying glass to examine the edge as the sharpening progresses. The operation requires patience, but the reward

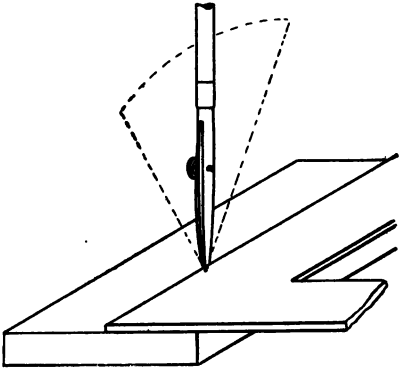


FIG. 39.—How to sharpen a ruling pen—first operation.

of a good pen is well worth the time spent upon it. The shape of the nib varies with the class of work to be done. If it is to be used for fine work, it should be quite pointed, if for coarser work, it can be well rounded and broad. It is commonly supposed that the wide flat pen as shown in Fig. 37 is to be used for heavy lines only. This is not so. Such a pen should be capable of drawing fine hair lines as well. Its chief advantage, however, lies in the fact that it holds more ink and is therefore better suited for long broad lines.

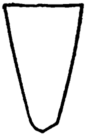


FIG. 40.—Effect of lettering.

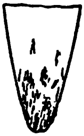


FIG. 41.—Corrosion on inside from lack of cleaning.

Many draftsmen use their ruling pens for lettering. This is an improper use of a good pen as it dulls the points very quickly and wears them flat on one side as shown in Fig. 40. However, if it is desired to use a ruling pen for no other purpose than lettering, there is one advantage, namely: lettering properly done with a ruling pen is very even and is not cut into the paper as it is with an ordinary lettering pen.

After using a pen it should *always be wiped perfectly clean and dry* with a soft cloth before laying it back in its case. Not a particle of ink should be allowed to remain on the steel blades because ink will corrode the steel and hinder the free flow of ink to the point, thus ruining the good quality of the pen (see Fig. 41). It is a good plan to rub the points of the pen lightly on a fine stone before laying it away. When it is desired to remove the thumb-screw and spread the blades for cleaning, the blades should be pressed together first between the fingers of the left hand and the thumb-screw run out with the right hand, so as to relieve the threads of unnecessary wear.

Some good pens are manufactured with a hinged blade to facilitate cleaning. An excellent pen is the pen illustrated in Fig. 36 and made by Theo. Alteneder. The blades are cut from one piece of high grade steel, the outer blade being a spring which holds the two blades constantly together against the pressure of the left hand thumb-screw. By means of a small lever, the blades can be quickly separated for cleaning without disturbing the adjustment of the pen for width of line. Since it is imperative in doing good work to keep the pen clean on the inside and supplied with fresh easy flowing ink, the advantage of this lever pen in permitting frequent cleaning of the blades is obvious.

Recently pens have been provided with a graduated thumb-screw to permit resetting of the blades for a certain width of line, as illustrated in Fig. 35. This is a good idea, however, it is not a difficult matter to graduate the screw of any pen not so provided, by means of an engraver's tool and a little careful work.

Many forms of *dotting pens* are made but they are not a general success. The dotting or wheel pen consists of two nibs like an ordinary drawing pen. Between the nibs a pin is fastened on which the toothed wheel is mounted. The ink is filled in between the nibs just as with the common pen.

BOW-SPRING INSTRUMENTS.

Under this heading are included the bow pencil, bow pen and bow divider. They supplement the large compass and divider and are indispensable

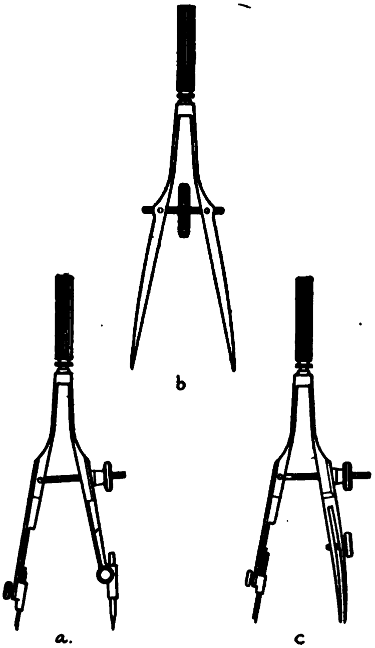


FIG. 42.—Bow-spring instruments.

for small work. They should be made of one piece of steel, properly tempered so that the legs can be pressed together easily between the thumb and finger and still be stiff enough to keep the points always rigidly in place.

The temper of the springs is so important that it cannot be emphasized too much. In most instruments the springs are too strong. If properly tempered, the " feel " of the spring is " just right " and it is a pleasure to handle it.

The bow pen and pencil are used to make small circles and arcs. For repeating small circles such as rivet and bolt holes these instruments are absolutely necessary. It is not difficult to understand how awkward it would be to try to draw circles ⅛ in. in diameter or less with the ordinary 6-in. compass.

In adjusting these instruments, where the adjustment is considerable the legs should *first be pressed together between the thumb and the finger* of the left hand and the thumb-nut run quickly to the required position by the right hand. The finer adjustment can then be made by the thumb-nut alone. In this way the adjustment is much more quickly made and the delicate threads of the screw are relieved of unnecessary wear.

Bow-spring instruments with center adjustment are manufactured as shown in *b*, Fig. 42. The screw threads are cut right and left hand in order to provide for more rapid adjustment. However, the adjustment is no more rapid than that of the usual instrument as described above, though the legs are probably held in place more securely.

The screw threads of all these bow instruments ought to be oiled occasionally, care being exercised to leave no excess oil which might soil the fingers or the paper. Good sewing-machine oil will answer, although the best instrument oil is 3-in-1 gun oil.

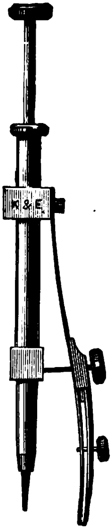


FIG. 43.—Drop-spring bow pen.

An instrument is made which is called the *drop-spring bow pen* (Fig. 43) and which can be recommended only for use in drawing a great number of small circles, such as for rivet heads, bolts, etc. It is a clumsy instrument, but for the above use is preferred by some. It consists of a spring bow pen, in which the pivot leg is tubular and has a stout needle point fitting loosely in it, with a milled screw at the top. To use it the needle point is inserted in the paper and the inking pen is spun around, with the fingers—its own weight being just enough to make a good line.

PENCILING.

The best combination lead pencils made are Hardtmuth's "Koh-i-noor" and A. W. Faber's "Siberian." They are of uniform hardness and intensity, are not brittle, and can be bought in several grades. For detail drawings use pencils ranging from 6 H to 3 H—the largest number indicating the greatest degree of hardness of the lead. 2 H and H pencils are used for architectural drawings while F & H B pencils are quite soft and are used for sketching and writing.

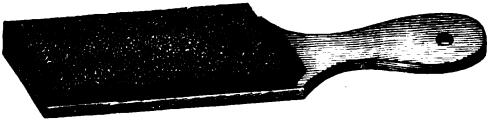


FIG. 44.—Pencil pointer.

In penciling a drawing use a hard pencil (about 6 H) for center lines and a softer one (about 4 H or 3 H) for details. Lines should be as fine and as light as possible and still be clearly visible for tracing. Do not bear down so hard as to leave a crease in the paper which cannot be erased. Use a wedge shape or duck bill edge for center lines and a conical point for details, marking and lettering. For pointing or edging the lead, use fine sandpaper, Fig. 44, or a fine file. Always draw the pencil along the paper—never push it. Be sure the T-square and triangles are held firmly against the guiding edges and against the drawing paper before drawing a line. When the pencil becomes too short to handle easily, use a pencil holder, which is a hexagon handle, with a ferrule at the end into which the pencil can be screwed (see Fig. 45.)

In using the compass, the legs should always be set at right angles to the paper, otherwise the line drawn is apt to be uneven or untrue. Lean the compass slightly in the direction of rotation and bear lightly on the pencil, but not on the needle point. When many concentric circles are to be drawn, use a *horn center* (Fig. 46) to prevent the needle point from wearing a large hole in the paper. This is a small disc of horn or celluloid which can be fixed above the center on the paper by means of three fine needle points. It is a very useful instrument.

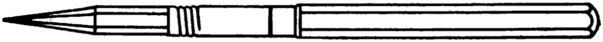


Fig. 45.—Pencil holder.

Use fairly soft leads in the compass (about 3 H) because the pivot joint is not firm enough to permit of such pressure on the lead as can be exerted on an ordinary pencil. Set the adjustable needle point to match the pen point in length and make the lead agree with this; then the needle point will never need further adjustment.

Above all things keep your paper clean by brushing off the dust and dirt as it collects. A sponge rubber or square of art gum applied frequently will clean off dirt and not disturb the drawing. The best way to prevent dirty drawings is to work fast. Cover your drawings well when leaving them for the night.

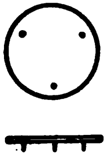


FIG. 46.—Horn center.

INDIA INK.

Drawing ink should be free from acid, should be absolutely black and opaque, and should adhere to the paper when dry, even if rubbed over. It should be free from foreign particles, should flow easily, dry quickly and should be waterproof, that is, insoluble when dry. Many kinds of prepared liquid ink are manufactured—one of the best is Higgin's which can be bought in bottles with stoppers provided with quills for filling drawing pens, or in larger quantities if desired.

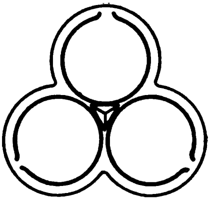


FIG. 47.—Clover leaf inkstand.

However, if you wish an extra good ink for some special work, make it yourselves as follows: Dip the end of a stick of the best India ink in a cup of distilled water and grind it on a porcelain slab or saucer. Continue the operation until the ink is of the proper intensity of color, being careful to rub no large particles off the stick. Filter through filter paper. Do not prepare more than is needed at the time. The best India ink stick is deep brown in color, fine grained and has a conchoidal or shell-like fracture. It is usually scented with musk or camphor and is ornamented with finely mounted Chinese characters. It will crumble if left moist; therefore dry the stick well after using. Ink prepared as described above should be used immediately after mixing.

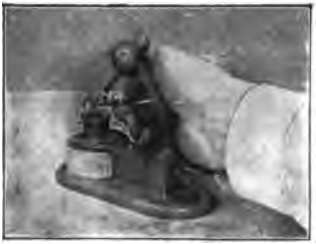


Fig. 48.—Pen-filling ink-stand.

Colored inks may also be purchased, green, purple, brown, blue, red, etc. These colored inks are used not so much to represent different kinds of material as to distinguish one material from another employed on the work.

One of the best ink stands manufactured to hold the common Higgin's ink bottles is the cloverleaf ink stand illustrated in Fig. 47.

Alteneder's pen filling ink stand is a clever device which holds the bottle, keeps the ink from evaporating and permits filling of the drawing pen with but one hand. (Fig. 48.)

INKING.

To ink in a drawing well requires care and experience. Practice inking straight lines of various widths and remember *to allow no ink to collect on the outside of the nibs of the pen.* This is fatal. Corners and intersections should be sharp. Stop lines at the right points and do not over-run.

Ragged lines and poor intersections show careless drafting. If the line is ragged, either the nibs are not sharp, are not of the same length, or both are not held down on the paper. The shorter or dull blade leaves its side uneven. The pen should be filled with a brush or quill, the latter being preferred. Do not overload the pen as the ink is liable to flow too freely and blot, however, be sure there is enough ink in the pen to rule the entire line. If through any cause, you have not enough ink in the pen to finish the line, stop it at some intersection point, and then refill. Always try the pen on a similar piece of paper before drawing with it. Clean and refill the pen frequently, but never directly above the drawing. Hold the pen in a plane at right angles to the paper, thumbscrew out and flat blade against the ruling edge and incline slightly in the direction of motion. The best of pens will make poor lines if improperly held. Both blades should touch the paper. Do not press the pen hard against the square, as the line will then be of uneven width. See that there is no dust in the path of the pen before starting the line and always try to ink in an easy position, even if it is necessary to turn the board around to get into such position. Experience alone teaches the wisdom of this. When several lines meet in a point, always ink toward it and if no harm is done stop the lines before they meet.

Let one dry before inking another intersecting it. Ink in the top and left hand lines first, that is, work down and to the right. This saves time waiting for inked lines to dry and often explains the difference between a slow and a rapid workman. Sometimes, and only when working in great haste, the hole in a large triangle can be placed over a section of the drawing to be inked, and with the aid of one of the small triangles, the inking can be continued without waiting for the ink to dry. If possible, ink in all lines of the same width, with the same setting of the pen. Ink in circles and arcs first, as it is easier to connect a

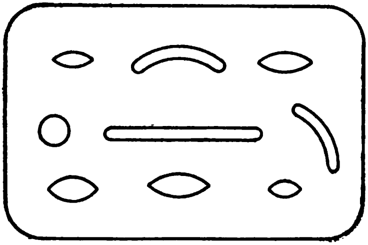


Fig. 49.—Erasing stencil.

straight line to an arc than vice versa. When a spot is erased it should be smoothed over by rubbing with a polished surface before inking again. A perfectly clean finger nail will suffice for this purpose. For erasing it is better to use a rubber than a knife or scraper, because the paper is left in better condition for receiving ink again. A very useful tool for erasing is the stencil, (see Fig. 49) which is a thin piece of sheet metal or celluloid, with different shaped holes in it to confine the erasure to a given space. The eraser for ink is a preparation of vulcanized rubber and powdered glass.

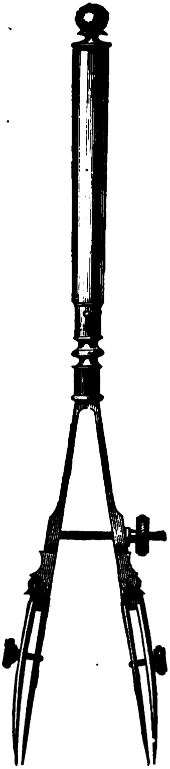


FIG. 50.—Railroad pen.

For lettering and dimensioning a drawing a great variety of pens are used. The important point is that letters and figures should be easily read; hence make them plain, distinct and uniform. As before mentioned, it is poor practice to use a good ruling pen for lettering. Pens are manufactured for fancy lettering and for special work of various kinds, but for ordinary drawings, they are of little use.

The writer has found it very effective to take the temper partially out of the nib of an ordinary long-nib writing pen by heating it with the flame from a match. This makes the line drawn by the pen much more uniform, and somewhat heavier.

Several devices are made to facilitate drawing the letters of the alphabet, some of which have already been described under the heading of triangles (see Fig. 16).

If it is found that ink flows poorly on tracing cloth, the cloth is either too smooth, greasy or cold. This can be remedied by rubbing the surface with finely powdered pumice, on a cloth. Simply breathing on the surface will often suffice to make the ink flow freely.

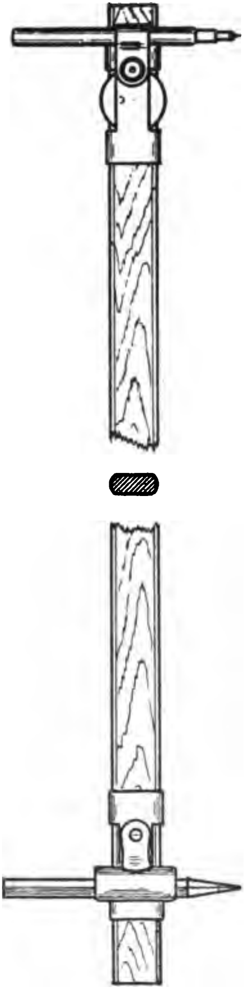
In making maps and in plotting railroad surveys the *road pen* (see Fig. 50) is a great convenience. It is simply two pens joined by a spring to a handle, and is used to draw road lines and the lines of railroad tracks.

THE BEAM COMPASS.

A beam compass is a compass for describing large circles up to six feet radius. It consists of a long bar of wood or metal with adjustable needle point at one end and a pen or pencil holder at the other.

One of the simplest, cheapest, and best beam compasses manufactured is the one illustrated in Fig. 51. It consists of a wooden bar on which is mounted a sliding frame to hold the pencil or pen. This frame fits the beam snugly but can be moved back and forth with ordinary hand pressure. It holds the ordinary pencil or ruling pen by means of a common paper clip. At the pivot end is a disk with eccentric pin, by means of which a fine adjustment can be made. The simplicity of the entire outfit appeals to all who see it. It is serviceable for arcs up to about 30 in. radius. For longer radii, and for wider range the Swiss beam compass is recommended.

More elaborate and expensive compasses are made, such as the one here illustrated, which is a most excellent type of the Swiss design. For such an outfit the beam should be made with a shoulder on it as illustrated in section, to prevent the movable metal riders from falling off while being adjusted. Fig. 52 shows the beam and parts correctly assembled. The great advantage of this design is its adaptability to any number of



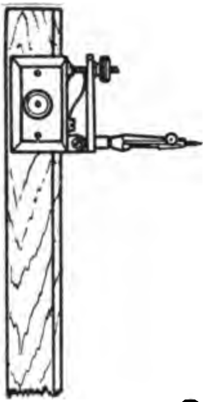
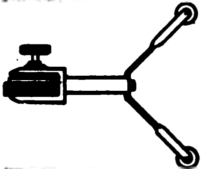


FIG. 52.—Swiss beam compass.



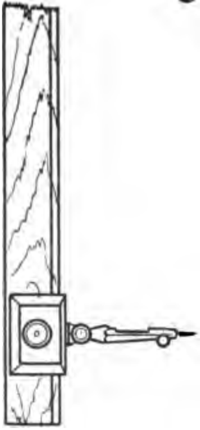


FIG. 51.—Simple beam compass.

beams. If necessary it can be used with any ordinary straight edge, although the regular beam section is stiffer and allows the attachments to be moved along without danger of falling off.

Beam compasses are made, in which the beam is made up of a series of tubes, each fitting into the end of any other section. They make a very portable beam, though somewhat more clumsy to handle.

IRREGULAR CURVES.

French curves or *irregular curves* (see Fig. 53) are such as are used in the ordinary work of an architect's or engineer's office, for rounding off lines of a machine or laying out ornamental work. There are many shapes—one or two will usually suffice for the average drafting room, When

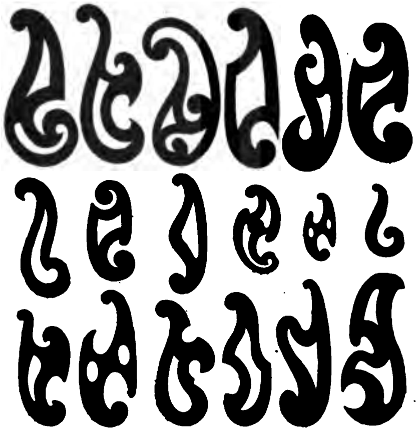


FIG. 53.—Irregular curves.

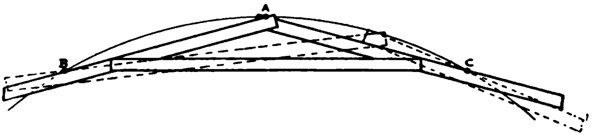


FIG. 54.—How to draw an arc of large radius through three given points.

symmetrical curves are to be laid out to the right and left of a given center line, it is customary to mark that part of the curve which is used with a pencil line so that the symmetry is perfect. The writer has divided and numbered his curves symmetrically on both sides with figures covering the entire curve, so as to facilitate duplication.

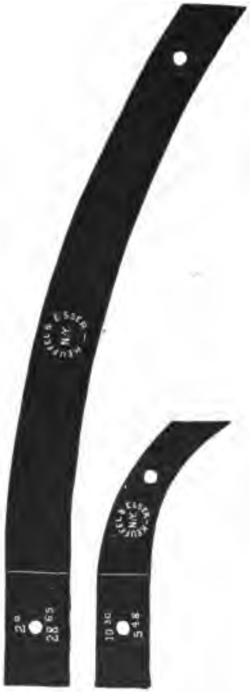


FIG. 55.—Railroad curves.

Many experiments have been made for the production of curves of large radii by means of instruments. The subject is one of great interest because of the many important operations into which such curves enter—as for example the projection of spheres. The geometrical proposition that "all angles in the same segment of a circle are equal" has been utilized for this purpose and is sometimes used by an intelligent workman in the shop, who wishes to draw an arc through three given points. Three pieces of wood are fastened together in a triangle so shaped that the apex of one angle corresponds with the middle point, and the sides of the triangle touch the other two points respectively. The arc is drawn by tracing the path of the apex of the triangle—always keeping the sides against two pins placed over the other wo points. (See Fig. 54).

In practice, to produce curves of large radii it 's most convenient to have a set of templates made of wood or cardboard, which can be bought in sets. These sets are called *railroad curves* or *radii curves* (see Fig. 55) and each one is marked with a number indicating the length of the radius in inches. They vary in length from 1½ in. to 18 in. and the radii from 2½ in. to 250 in. Some are made with tangents to the curves, these being especially valuable to surveyor's on railway work.

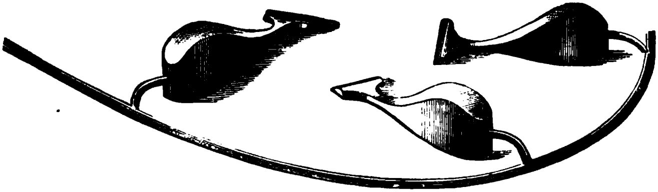


FIG. 56.—Weights and splines.

Splines are flexible curved rulers which can be made to conform to any ordinary curved line by means of weights, as illustrated in Fig. 56. They are made for ship builders.

As a general rule, except in these special industries, it is advisable to use definite arcs of circles for irregular curved outlines so as to facilitate their exact reproduction in the finished pattern, *Ship curves* (Fig. 57) are such as are used to draw the lines of the framework of vessels. They are curves derived from the parabola, ellipse and helix. One curve will not usually give the entire curvature of the rib of a ship, but by piecing two or three together carefully the whole curve can be drawn.

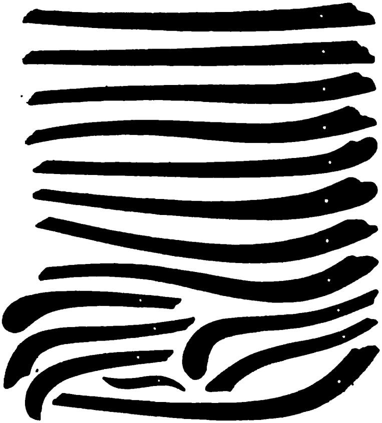


FIG. 57.—Ship curves.

THE SLIDE RULE.

The slide rule (Fig. 58) is an instrument for performing mechanically all of the ordinary calculations required by the calculator. By its means complicated problems of multiplication and division are solved rapidly and accurately to three or four digits, depending upon the kind of rule used. Square and cube roots can be extracted, proportions can be solved, sines, tangents and the cofunctions of angles can be determined and logarithms of numbers can be found. The principle upon which the slide rule depends is the logarithm. To multiply any two numbers we add their logarithms and obtain the logarithm of the product. To divide one number by another we subtract its logarithm from that of the other and we have the logarithm of the quotient. Hence in the operation of a slide rule, we add and subtract logarithms of numbers, the divisions on the rule being such as to represent the logarithms in length.

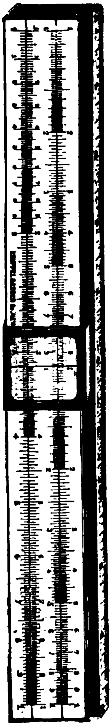


FIG. 58.—Slide rule.

The slide rule is a very useful instrument indeed. Its applications are innumerable. It is most excellent for work which does not permit or require absolute accuracy. Calculations can be rapidly made with it in the field. For gear work, figuring weights of castings, estimating costs, checking accounts, engine work, calculating areas and circumferences, figuring bevels, etc., it has great value. Every engineer needs one. Various kinds are made. Some are cylindrical, some shaped like a watch. The usual form, however, being that of a rule about 10 in. long with a graduated slide working in grooves as shown in the accompanying cut.

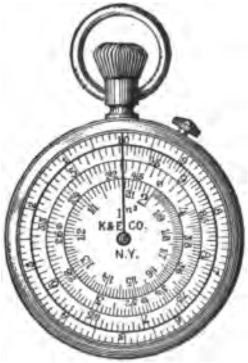
Before purchasing a slide rule, test it for a variety of operations on each scale and also note whether the divisions " line up " on the adjacent scales when the rule is set at 0.

Boucher's Calculator.

(Fig. 59.)

" For approximate results, there is no instrument so handy as this. On the front face, a logarithm scale is engraved in four lines which is equal to a fourteen-inch straight slide-rule scale. It is a circular slide rule. The gauge points as they are termed give indices for numerous calculations with no effort of memory nor reflective power to execute the dependent operations when our school learning by rote is forgotten.

"*Professor Fuller's slide rule* represents, perhaps, the highest refinement in this class of rule, capable of greatly facilitating the numerous arithmetical calculations required by the engineer or architect. Its range is greater than most arithmetical machines; since besides the operations of multiplication and division which many instruments can only perform, results requiring reciprocals, powers, roots of logarithms of numbers can be quickly and easily obtained by its use. (See Fig. 60).



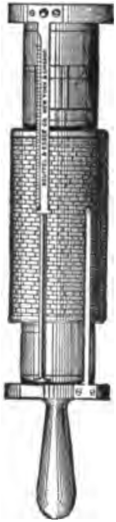


FIG. 59.—Boucher's calculator. FIG. 60.—Fuller's slide rule.

" The rule consists of a cylinder that can be moved up and down upon or turned round an axis, which is held by a handle. Upon this cylinder is wound in a spiral, a single logarithm scale.

Fixed to the handle is an index. Two other indices whose distance apart is the axial length of the complete spiral are fixed to the cylinder. This cylinder slides in like a telescope tube and thus enables the operator to place these indices in any required position. The stops are so fixed that when they are brought in contact, the index points to the commencement of the scale.

"The use of slide rules has been confined to roughly approximate calculations as the length of scale hitherto made was sufficient only for about 160 divisions. In the above rule, the length of scale is 500 inches and the number of divisions 7250, consequently the approximation obtained by its use is sufficient for most of the calculation required by engineers or architects."

THE PROPORTIONAL DIVIDER.

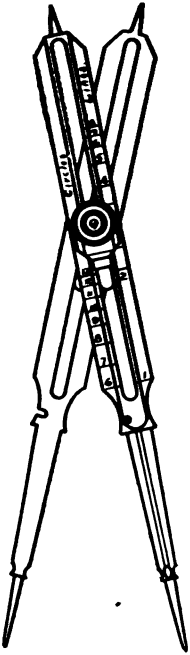


FIG. 61.—Proportional divider.

A proportional divider (see Fig. 61) is an instrument for enlarging or reducing drawings by direct measurement and for dividing a circle into equal parts. As illustrated, it consists of two legs pointed at each end and hinged somewhere near the middle. The hinge joint is made adjustable to suit any ordinary ratio of reduction or enlarging which may be desired. On one leg is a stud which fits into a groove in the other when closed, so as to prevent shifting of the leg when setting the instrument. The legs are graduated to facilitate rapid adjustment. The graduations are for lines and circles respectively. The scale of lines is used to reduce or enlarge drawings in a definite proportion. If a drawing is to be reduced $\frac{1}{3}$ or enlarged 3 times, the line on the slide is set to the division marked 3 in the scale of lines. The scale of circles is used to divide circles into a number of equal parts. If the line on the slide is set to a given division on the scale of circles and the slide clamped, then for any circle whose radius is the opening between the long legs, the shorter legs will divide its circumference into that many equal parts. On account of the danger of breaking or wearing the points of proportional dividers (thus destroying their accuracy,) the points are made quite blunt and sometimes are turned over at right angles to the leg to insure continued accuracy.

THE SECTION LINER.

Many devices have been invented for uniform section lining. Most of them are more bother than they are worth. It is much more satisfactory to train your eye to do such work evenly than to spend time adjusting a section liner. One of the commonest makes is illustrated (Fig.62). Where very particular work is desired, it is well enough to spend the time to use one. The great fault with them is that they cover so limited a space that frequent settings are necessary.

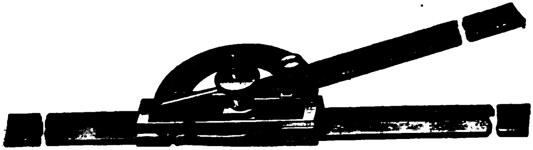


FIG. 62.—Section liner.

THE ELLIPTIC TRAMMEL OR ELLIPTOGRAPH.

The elliptic trammel (see Fig. 63) is an instrument for describing ellipses. It is made up of a metal base in the shape of a cross, with guides along each arm, in which two pivoted lugs projecting from the beam can move. The beam carries at one end a socket either for a pen or pencil. Projecting from the under side of the base are short holding pins, which prevent any movement of the cross when describing an ellipse.

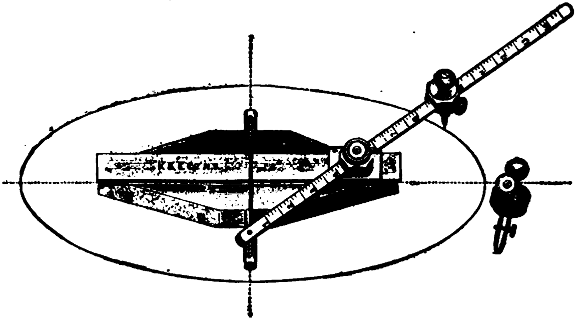


FIG. 63.—Elliptograph.

To produce a given ellipse, mark off one-half the major and minor axes on two lines at right angles to each other. Set the base of the instrument on these lines so that the separate axes correspond with those on the drawing. Loosen both the sliding heads of the beam and place the beam in line with the major axis. Set the pencil to the half major axis point and clamp the sliding head at the center. Now move the beam around in line with the minor axis, and set the pencil on the half minor axis point. Clamp the other sliding head and proceed to describe the required curve. A stiffness of movement will be observed while passing the axial positions, producing some irregularity at these points. The instrument is used practically by photographers for describing ovals for photographs.

THE PANTOGRAPH.

The pantograph is an instrument for reproducing figures of any shape in smaller or larger scale by tracing the original outline directly. It is a copying instrument. It consists of a fixed point—a movable tracing point, and a pencil or ink attachment moving parallel to the tracer. The cut (Fig. 64) shows the instrument in its simplest form. It consists of four graduated rules jointed together in pairs to form an accurate parallelogram. The pantograph can be set to reduce drawings in two ways—the erect and the reverse reduction—depending upon the relative positions of the several points. In using the instrument some care is required to set the fulcrum in the best position to allow for easy action and for covering the required space. The tracing point should be run along the outlines of the figure roughly at first to be sure the setting is right.

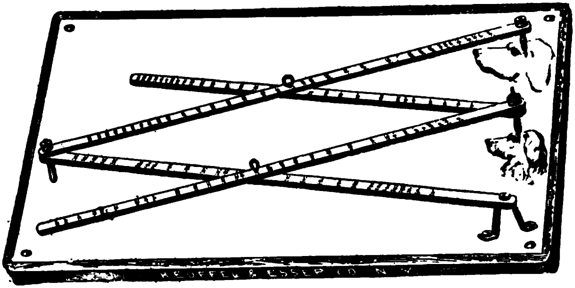

KEUFFEL & ESSER CO. N.Y.

FIG. 64.—Pantograph.

THE PLANIMETER.

The planimeter is a very exact scientific instrument for measuring areas, invented by a Swiss professor, named Jacob Amsler.

Of all the mechanical devices for computing, the planimeter ranks first as the most ingenious and useful to the engineer. It measures by the simple act of tracing the outline, the area of any plane figure, however, irregular, as indicator diagrams, profiles, plans and sections. The perfection of its use depends only upon the skill of the operator in following out lines. There are two kinds, polar (Fig. 65) and rolling planimeters (Fig. 66).

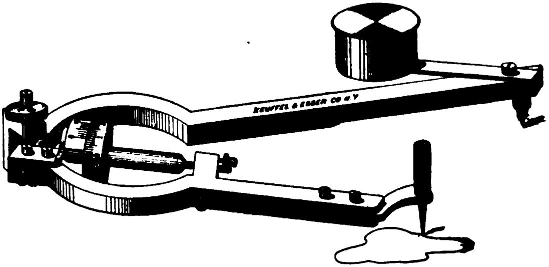


FIG. 65.—Polar planimeter.

The *polar planimeter* consists of two main parts, the tracer arm carrying the tracing point and the carriage with the measuring wheel; and the pole arm to the end of which is fastened the pole about which the instrument revolves. The area of the figure is quickly and accurately obtained by tracing the boundary line with the tracing point—the result being indicated directly on the graduated wheel. A planimeter is a mechanical integrator, *i.e.*, it sums up all the infinitely small areas, which make up an irregular figure. It is manufactured with a fixed scale which reads only in square inches and also with an adjustable scale to conform to the scale of the drawing which is to be measured. It is impossible here to explain the theory of the planimeter—it is sufficient to say that the theory involves the principles of calculus, which the reader can investigate by referring to more elaborate treatises on this particular instrument, (see Vol. 1 of Nichols and Franklin's Elements of Physics, Pg. 6). The accuracy of a planimeter can be tested by tracing a figure of known area, as for instance a square whose sides are 1 in. long, and whose area is one square inch.

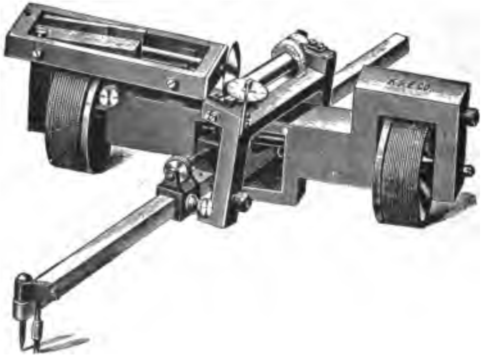


Fig. 66.—Rolling planimeter.

DRAWING TABLES.

Many kinds of drawing tables have been designed for use in the drafting room. Some of them are good but are suitable only for certain conditions. Of those which are now on the market, the best and most practical for all general purposes are those manufactured by the Economy Drawing Table Co., who have devoted considerable thought to the design of tables which are practical, serviceable, neat and well made. These tables are built in several forms and sizes, to suit designers, detailers, architects, schools, etc. (see Fig. 67). In

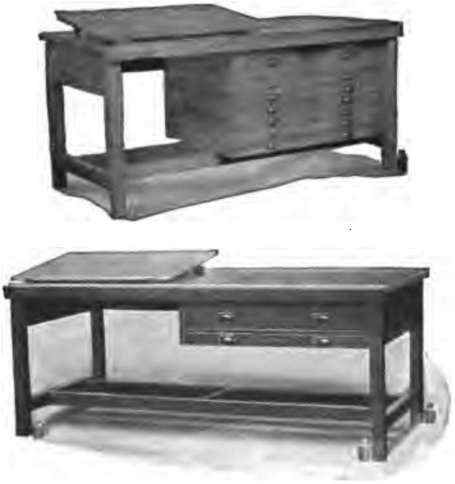


FIG. 67.—Economy drawing tables.

their larger sizes they provide room for the drawing board and also room for reference drawings. The table top itself is suitable for work with very large drawings, and the drawer files and tool drawers are very conveniently located making the whole a compact equipment.

Some drawing rooms are equipped with vertical drawing boards as illustrated in Fig. 69. These boards have several items to recommend them.

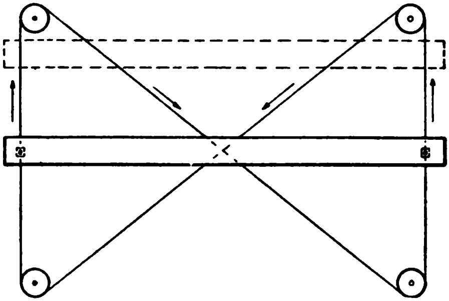


FIG. 68.—Parallel straight edge.

Most important is the fact that the draftsman does not need to bend over his board—he can work, while sitting or standing in a normal and comfortable position. One objection is this—a man has to handle his tools much more often and awkwardly, so they are very apt to drop on the floor and get out of true. The board is mounted on a framework which can be tilted back at several angles, or laid flat on the table for dimensioning and lettering. The straight edge used with the vertical board is really a parallel ruler. It consists of a wooden blade, fastened at both ends to a continuous chord system passing over sheaves set into the side frame, by means of which a parallel motion is secured as illustrated (Fig. 68).

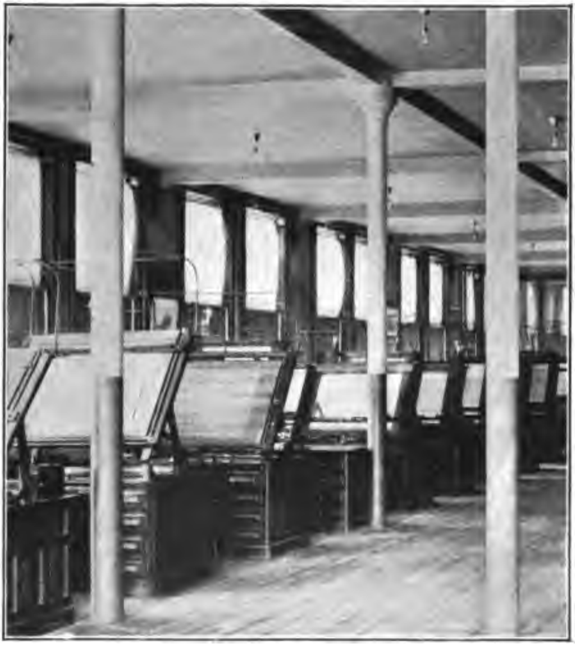


FIG. 69.—Vertical drawing board.

THE PLANE TABLE.

"The plane table (Fig. 70) forms a surveying instrument and drawing board in combination. A plan of a plot of ground by its means may be directly plotted on the field, or angles and distances only may be taken for this plotting and represented on the paper in graphic form so that no field book is required with it. The plane table is seldom used except for topographical or military surveying. One of its merits is that its use can be easily taught to persons unskilled in exact drawings.

"The plane table in its simplest form consists of a small drawing board mounted upon a firm portable tripod stand with a sighted rule termed an *alidade* to give the direction of the objects to be plotted on the paper laid on the table. The alidade carries a small telescope which moves on an axis parallel with the ruling edge.

"To use the plane table in the ordinary way, it is fixed level at some convenient position where the ground to be surveyed can be seen. A sheet of paper is then pinned upon the surface. A fine hole is placed in the paper to represent the station of the board. From this hole, lines are drawn to represent magnetic north to south. Lines are then drawn from this station to every point intended to be represented on the plot, which lines may be measured off by the chain and plotted to scale."

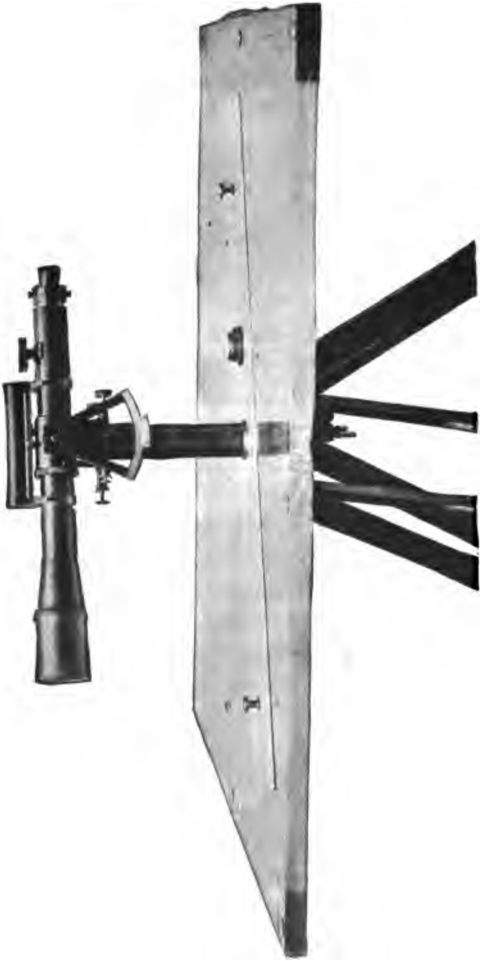


Fig. 70.—The plane table.

BLUE PRINTS, BROWN PRINTS, ETC.

Copies of tracings can be easily and cheaply made by several processes, all of which are similar in principle. The usual process is that of blue printing, in which the tracing is laid flat (and right side up) upon a piece of paper especially prepared with a solution which is sensitive to light and which is made insoluble in water by the action of light, The two papers in contact are commonly placed in a wooden frame with glass front (see Fig. 71) and are clamped tightly together. The whole is then exposed either to sunlight or to the rays of the arc light until the chemical change in the sensitive film has proceeded to the proper point, which is easily determined by practice. The paper is then removed from the printing frame and washed well in water. The insoluble solution remains, while the soluble portion is dissolved, giving the white lines on a blue background. The print is then dried and trimmed.

On account of the necessary dependence on sunlight of the old sun process a number of excellent blue printing machines have been developed, which make the blue printer to-day entirely independent of sunlight, and which increase the capacity of the establishment enormously. All of them depend either upon the arc light or upon the mercury-vapor arc light whose rays are found to act in the same way upon the blue printing solution (see Figs. 72 and 73).

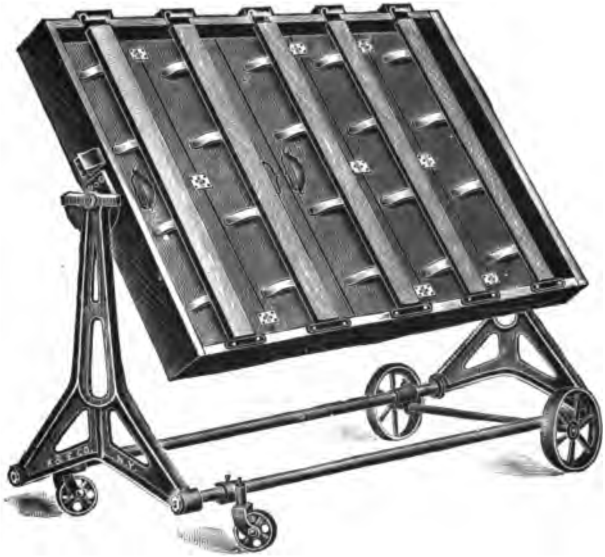


FIG. 71.—A sun-print frame.

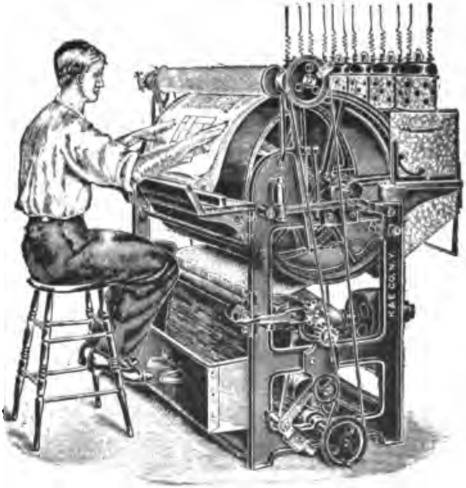


FIG. 72.—The Federal blue-print machine.

MADURO PRINTS.

An important process has been put forward lately—commonly called the brown print process, by means of which a negative print can be made which can be used the same as a tracing for making further prints. This process is particularly valuable where slight changes are to be made in a tracing. The brown print is made to preserve a record of the original tracing after which the tracing can be altered as desired.

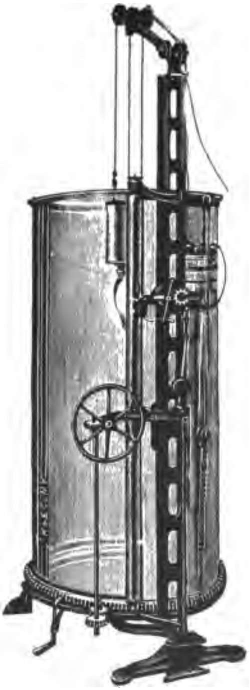


Fig. 73.—K. & E. vertical print machine.

Sometimes the brown print is made (by blocking out the portions to be altered) so that the changes desired can be drawn in ink on the space blocked out. Then the original tracing need not be changed.

The objection to the brown print is that it is not as permanent as it should be. It fades considerably when laid away for a long time.

When prints are to be made for hard usage, a cloth instead of a paper body is used. It might be well to mention here that when it is desired to make unusually good blue prints, no electric blue-printing process can equal the old fashioned sun print for beauty and sharpness of contrast—made on blue print paper which has been freshly prepared.

When it is desired to alter a blue print by the addition of a figure or letter, it will be found convenient and satisfactory to use a solution of gum arabic and soda applied with a pen, like ink. This will make a white line on the blue background.

DRAFTING ROOM PRACTICE.

In essentials most drafting room practice is very similar. All concerns adopt uniform sizes for their drawings and tracings, usually making the largest sheet about 24 in. by 36 in. and the smaller ones—one half and one quarter as large for convenience in filing. Around each tracing is ruled a heavy border line—the border varying in width from ½ inch to one inch. The right hand lower corner is reserved for the title, which is usually printed in by the draftsman on a stamped form. This form may be put on to the sheet by the draftsman himself, with an ordinary rubber stamp, or the sheet may come to him already stamped with title-form and border-lines. The form usually displays the name of the concern—their address, the contract number, the title for the drawing, the draftsman's initials, the scale of the drawing, the initials of the checker, the date and the number of the drawing. Sometimes space is allowed for an approval signature, or several of them.

The number of the drawing is placed in the extreme right hand corner of the stamp and sometimes the same number is placed at an opposite corner so as to facilitate recognition from all sides. The drawings are filed in cases according to numbers. Very often the contract number and also the drawing number are combined thus 452-7 which would mean drawing number 7 of contract 452.

Every drawing should be made so as to give a complete conception of the thing to be made and *no more.* How much should be shown is often a vexing question. It is better to err on the side of showing too much than too little. The arrangement of the parts should also be a matter of study before beginning to draw, as a pleasing appearance as well as an economy of space are very desirable, and show a careful workman to good advantage.

After marking out the inside border line of the drawing on manilla paper it is well to lay out the clearances for title, number space, etc., so that in working, this space will not be used by mistake. Estimate roughly the sizes of the various views to be made, and if necessary block them out on the paper so as to be sure they will all be included. Usually more than one view is necessary to show the details clearly—a front elevation, a side elevation and a top or plan view (see Fig. 74). Oftentimes in intricate work, one or more sectional views will have to be shown. A sectional view is one which shows the object as it would appear at that point if cut by an imaginary plane. In arranging these various views a definite policy should be adopted. The top or plan view should be above the side elevation and the right end elevation should be to the right hand side of it, etc. Furthermore, all sectional views should be made looking in the *same direction* whenever this is possible, and should be placed so as to indicate it. A common practice to show where it is taken is to draw a light line across the figure with arrows at either end to indicate the direction in which the section is taken. See Fig. 74.

When the object is symmetrical it is often economical of time and space to show but half of it as an end view and the other half as a sectional view. All sectional views should be cross sectioned at 45° and when the section shows several different pieces or materials, this should be emphasized by cross sectioning the adjacent parts with lines at right angles to each other. There are standard systems of cross sectioning which can be used and which are required by the U. S. Patent Office for patent drawings.

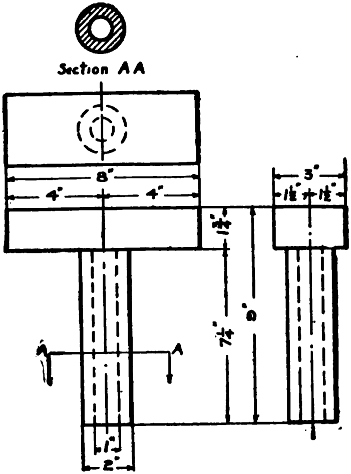


FIG. 74 —Detail drawing.

Much time can be saved on a drawing by dimensioning each part as it is measured and drawn. The line of the dimension may have to be moved in the tracing but the dimension is there, and the mental process of measuring does not have to be carried through again. To avoid confusion give dimensions up to two feet in inches, and dimensions above two feet, in feet and inches—separating them by a hyphen. Of course this statement does not apply to those drawings where the measurements are in feet and decimals of a foot.

Assuming now that the paper drawing has been completed, it is well before tracing it to consider carefully the general conditions which the parts drawn must satisfy. Some of these conditions are as follows: Safe stresses and strains, strength of materials, prices, cost of manufacture, lubrication, replacement, cost of maintenance, standard sections, no interferences, proper clearances, no inaccuracies, proper dimensions and notes, etc., etc.

In tracing a drawing it should be remembered, especially by the beginner, that a tracing is made for reproduction on printing paper. Consequently all the lines made should be *perfectly black* and should be heavy enough to print well. For speed in tracing, work from the top down and from left to right so as to avoid waiting for the ink to dry. Center lines should be fine black dot and dash lines and dimension lines should be fine full lines broken at the center to receive the dimension. This practice will save a good deal of time in replacing the line when an erasure of the dimension must be made. Never place dimensions or dimension lines in the body of the figure if it can be avoided and in giving a series of dimensions give the shortest ones closest to the figure so as not to cross lines unnecessarily (see Fig. 74). This avoids confusion.

Red ink lines are often used to represent center lines and also parts closely related to the detail shown. This is sometimes advisable but usually it is better to show the related part in an oddly dotted light black line because the black line will always show light on the print while the red line can be eliminated entirely by over-printing.

All lettering and dimensioning should read right, from the bottom and from the right hand side. For letters choose one or two of the standard alphabets, which have been demonstrated, to be those easiest to make free hand and simplest to read. Above all things the alphabet should be plain.

Bear in mind that an excellent drawing can be spoiled absolutley as far as neatness and beauty is concerned by poor lettering. Line out all the lettering to be done on the tracing by pencil guide lines correctly spaced. For a thoroughly practical treatise on free hand lettering for working drawings see Reinhardt's " Lettering for Draftsmen Engineers and Students."

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